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Differential and Developmental Aspects of Object - Perception

Jitka Lindén



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Differential and Developmental Aspects of Object-Perception

av

Jitka Lindén

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The dissertation includes a discussion of the theoretical background as well as three empirical studies exploring different aspects of object-perception. The first report focuses on differential aspects studied by means of analyzing individual differences in three situations: the size-invariance situation, the spiral aftereffect (SAE) situation and the Rod-and-Frame Test. The interrelations found are interpreted as reflecting a formal personality characteristic of differentiation. The second report, focusing on developmental aspects and involving 7.5 - 8.5 year old children relates SAE-duration to the intellectual understanding of this phenomenon and to behavior on Piaget's Coordination of Perspectives Test. The results are considered in terms of development toward objectivity. The third study consists of two successive follow-ups of Study II, each after a one-year interval. In addition to interrelations such as those examined in Study II, overall changes in behavior during this time are investigated, as are individual stability and patterns of change.

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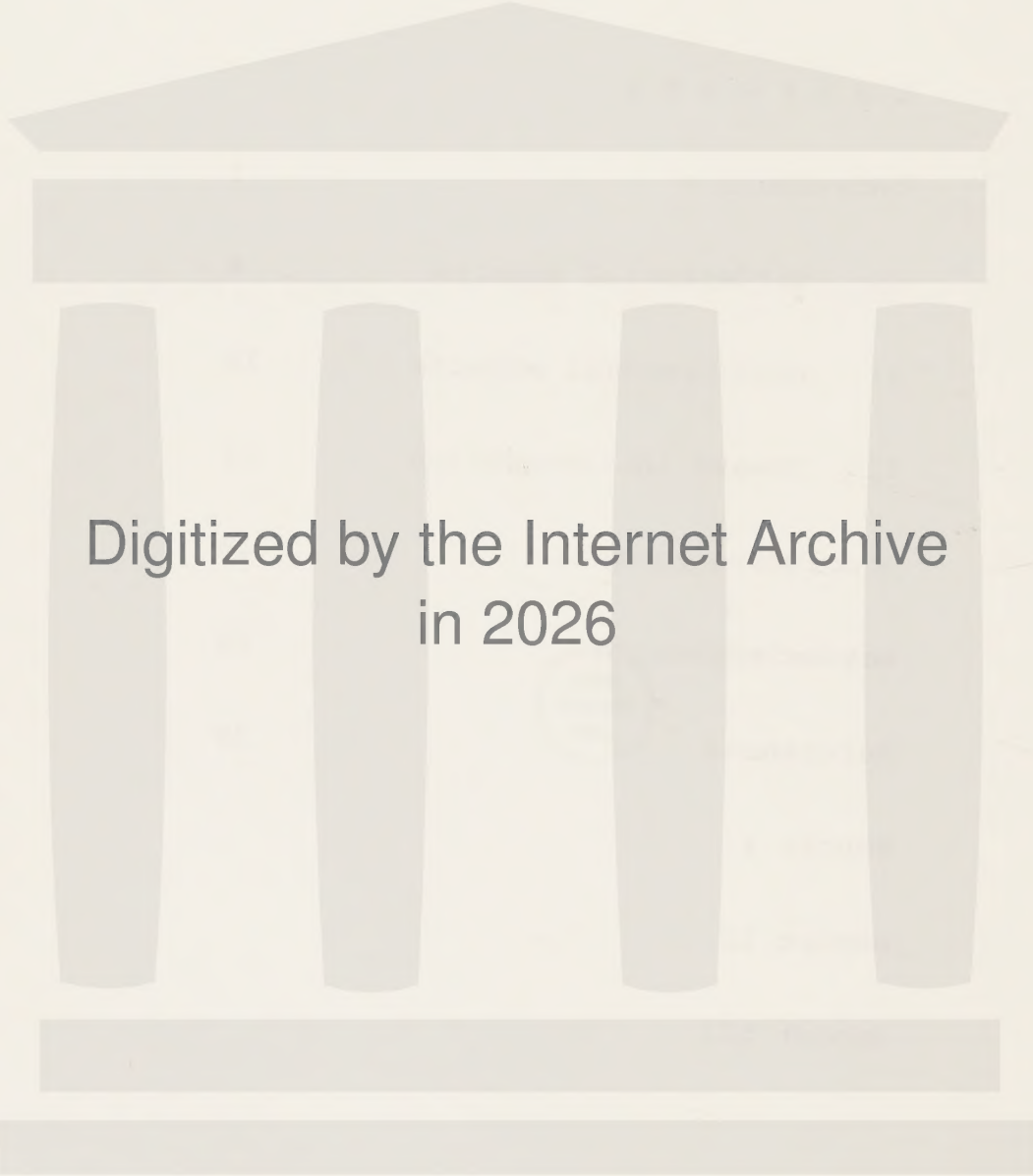
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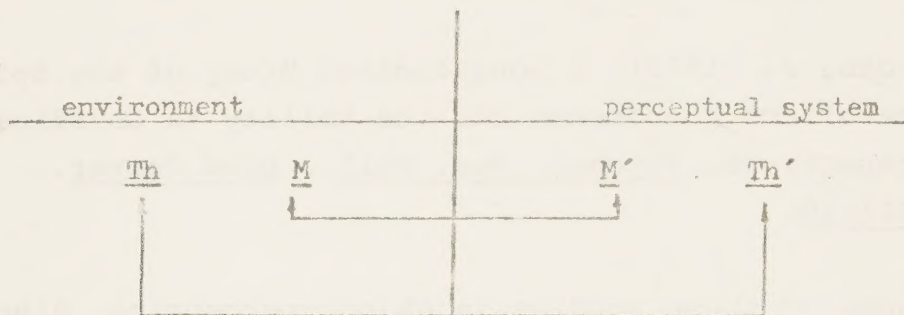
The empirical background of the present dissertation consists of three reports, referred to in that which follows as I, II and III:

- I. Lindén, J. (1976). Perception in Size-Invariance Situations as Related to Visual Aftereffect Perception and Rod-and-Frame-Test Performance. Psychol. Res. Bull., Lund Univer., XVI:4.
- II. Lindén, J. (1977). Children's Understanding of the Spiral Aftereffect Phenomenon as Related to Aftereffect Duration and Coordination of Perspectives. Psychol. Res. Bull., Lund Univer., XVII:1.
- III. Lindén, J. (1978). A Longitudinal Study of the Spiral Aftereffect Phenomenon and the Ability to Coordinate Perspectives. Psychol. Res. Bull., Lund Univer., XVIII:10.

The unifying theme of these studies is object-perception. Since this is explored in a variety of contexts, such as personality and development, the concrete focus of interest differs nevertheless from study to study. As a point of departure for presenting the three reports, some general approaches to object perception will be examined in order to illustrate the conditions under which perception may occur and be investigated.

A basic aspect of object-perception is that the physical existence of a distal object cannot be perceived directly. Using Heider's classical outline of perception (Heider, 1959) as a basis for analysis it appears that information about a distal object is transmitted through various mediating processes. (Fig. 1).

In a sense, however, the mediating region is irrelevant, since an environmental event can be mediated in different ways. More essential in the perceptual process is the invariance of the relations between Th and Th' , since under normal circumstances phenomenal appearance corresponds to a high degree with the world of things. Heider argues for the influence of the physical macrostructure itself as a factor in perceptual salience, the relationship between M' and Th' having the character of reconstruction. This relationship corresponds with the relationship between Th and M , the correspondence here being seen as illustrating the adaptive function of the perceptual apparatus. In this manner, tasks which the environment sets are solved effectively.



Th: The vitally relevant environment

M: The mediating events, the stimuli which directly impinge on the organism

M': The processes in the organism correlated to the stimuli

Th': Experiences which refer to things

Fig. 1. The schematic representation of the relation between the perceptual system and the environment (from Heider, 1959).

Although most researchers would probably agree with this general conception, various approaches differ in the emphasis they give to particular aspects of the scheme. The role assigned to the perceiver in the perceptual process and the question of the veridicality of perception are two examples of controversial issues that have been treated differently in various contexts.

Gibson's theory (1959) represents an approach stressing the veridical properties of perception, i.e. the correspondence between perceptual experience and stimulation. In terms of the theory, the main characteristics of perception concern its effectiveness in supplying an individual with information about the environment, an aspect which people recognize in everyday life. In Gibson's view, however, these characteristics of perception are the result of certain "local" properties of the perceptual apparatus. Concretely, the mathematical properties of the retinal image are considered sufficient to account for the correct perception of an object. All qualities of a distal object are seen as having a point-to point correspondence with proximal conditions in the retina, the perceiver's task being to pick up this retinal information. Obviously, this conception makes the perceiver's role in the perceptual process seem quite superfluous and, in consequence, research here focuses on an analysis of the stimulus. In Heider's system, on the other hand, it appears that the proximal stimulus has only a mediating role in the perceptual process. His distinction between the thing and the medium implies that the perceptual experience of an object requires the organism's active and selective participation in the perceptual process. This problem of perceptual selectivity, i.e. the question of how certain stimulus information becomes emphasized out of a whole field of potentially available information, is difficult to handle within the framework of Gibson's theory.

An approach to perception sharply contrasting with that of Gibson and of psychophysics is the early "New look" movement, which arose

in the USA after World War II (for a discussion of it see, e.g., Bruner & Klein, 1960). Its focus is on internal factors such as needs, motives, intentions, etc., and their role in the formation of perceptual experience. In fact, in the most extreme version of the New Look, perception was viewed as directly need-fulfilling. Many experiments were carried out aimed at demonstrating the corruptibility of perception by these factors (e.g. Bruner & Goodman, 1947, Bruner & Postman, 1947). Most such studies shared important theoretical and methodological weaknesses. Firstly, they were based on the underlying assumption of a simple (often linear) relationship between a need and its effect upon perception. The formula "what looms large in motive, looms large perceptually" illustrates well this assumption. Secondly, work of this sort was oriented towards the establishment of general laws applicable to all persons, individual variation being conceptualized as "error" and largely ignored. Obviously, such studies not only oversimplified the complexity of the motivational context but also neglected the importance of stabilized personality dispositions.

The criticism of the lack of a theoretical approach which would account for individual differences here (e.g. Klein & Schlesinger, 1949) resulted in a subsequent emphasis on perceptual attitudes (and the later consideration of cognitive styles and cognitive controls) as stable dispositions in the perceiver intervening between motives and the effects of these on perception. This idea of motivated perception had its roots in psychoanalytic theory, particularly in its ego-psychology. Of decisive influence here was Hartmann's notion of conflict-free functions and their autonomous development during ontogenesis, as well as Rapaport's work on ego-functioning. According to the viewpoint which thus evolved, people are seen as developing stable modes of meeting the world, namely ego-controls. These are represented in perception by perceptual attitudes which constitute the internally consistent "perceptual character" of each person. Thus, this conception aims to account

both for the individuality of personal solutions and for the environmental adequacy of such solutions, since they are conceived as structures which develop out of the necessity for the individual to achieve an adequate fit between perception and reality.

An attempt to integrate the adaptive aspects of perception (i.e., its responsiveness to the organization of objects) and its modifiability by motivation can be found in Klein (1970), who argues that motives range from those connected with the reality-oriented approach to those which are situationally nonadaptive or irrelevant. Motives aiming at effective object control are labeled executive intentions. They bring into awareness those object-properties which are necessary for effective action. The general correspondence between object structures and phenomenal experience is guaranteed through the process of executive intending having its basis in purposeful action. This correspondence is not simply a matter of stimulation but is the result of an active and constructive process within the individual. However, it follows from the structural properties of the perceptual apparatus (consider here the distinction between the thing and the medium) and from the diversity of the entire motivational field that there are situations where perceptual experience is dominated by motives which are largely peripheral. This occurs, for example, when the subject is confronted with equivocal, impoverished or conflict-laden stimuli or when he is in an unusual state of mind.

From the above discussion it should be clear that object-perception is a process of continuous relating between intraorganismic and environmental factors, a matter which cannot be understood exclusively in terms of the correspondence or non-correspondence between the object and the perceptual experience. Moreover, since it is not assumed that there is any absolute, correct solution to an adaptive task (its rather being a matter of personal fit relative to both the perceiver and the environment), an individual approach based on an adequate theory of personality organization is required.

I. Differential aspects

The aim of study I was to explore various aspects of the formation of perceptual experience, particularly those involving an interplay between "executive" and "peripheral" motives. Concretely, interest was focused on individual differences in coping with various types of situations involving the size-invariance task, perception of the spiral aftereffect and finally, the Rod-and Frame-Test situation.

The size-invariance (or size-constancy) phenomenon illustrates well the effective coordination of purposeful action, perceptual experience and object structures. It is well known that things appear of about the same size when placed at different distances from the observer, despite marked differences in the size of the retinal image. In other words, since the object-properties aimed at in everyday life are physical invariants, they can be expected to be in the focus of awareness. Retinal size, on the other hand, has only a mediating role in reality-oriented perception and is usually beyond awareness.

However, under certain conditions people can shift the experiential emphasis from the physical invariants to the retinal object-properties, this shift illustrating the selectivity of perception. Of particular interest in this connection was the finding that the usual executive intention (which is physical-invariance oriented) has a certain influence on the perceptual experience reported, even if the individual tries to see in terms of retinal properties. In apparent consequence of this, judgements made under these conditions tend to be intermediate in size between the physical and retinal sizes, although individual variation is great. In the size-invariance situation used here, the subject was instructed to shift attention from a set of cues usually in awareness (those indicating physical size) to others of which he would usually not be aware (those connected with retinal size).

The second situation consisted of measurement of the duration of the spiral aftereffect (SAE) by means of a technique developed by Andersson (see Andersson et al., 1972, for a more detailed presentation). Described in short, the standard test procedure consists of registering the duration of motion aftereffect experienced by the subject in ten repeated trials. The SAE-technique has previously been used in both personality and developmental contexts. Here, the focus was on a certain similarity between the perception of SAE, and the perception of retinal size in the size-invariance situation. Both are perceptual phenomena which do not fit easily into the framework of realistic everyday perception. In the size-invariance situation, the subject encounters the stimulus with a set formed under previous lifelong experience with physical objects; his task is to make this set peripheral and adjust perceptual experience to the instructions. In the SAE-situation, the subject must find a state of equilibrium between the influence of an "experimental" set (induced by previous stimulation from the inspection of the rotating spiral) and the stimulus circle on which the aftereffect is "projected".

Performance in the Rod-and-Frame-Test (RFT) has been interpreted as reflecting a cognitive style of field-(in)dependence, or more generally, a personality construct of psychological differentiation (Witkin et al., 1962). The physical setting used here consists of a square frame tilting 20° to the right and a rod pivoted at the frame's center. The subject's task is to adjust the rod to be in accord with the perpendicular. Individuals whose perception is termed field-dependent are considerably influenced by the perceptual context, the rod thus being tilted in the frame's direction. In contrast, field-independent individuals can overcome the frame's influence and adjust the rod to be more or less in a vertical position. Here again, similarities with the size-invariance task are evident. In both situations, there are conflicting cues, the subject being required to pay attention to only some of them. In the size-invariance task some cues indicate the physical object and others

the retinal object, whereas in the RFT there are visual and proprioceptive cues in opposition to one another.

Apart from the similarities, however, there are some important differences between the three situations. While in the size-invariance task the interference is between two sets of cues, one of them corresponding to the physical structure of things and therefore aimed at in everyday life, the RFT situation introduces discord between two sets of cues which usually are in accord, though neither of them is necessarily more "true" than the other. In addition, in the spiral aftereffect task there is interference between the circle-stimulus and "distorting" traces of previous stimulation. Other differences concern the instructions. Those used in the size-invariance situation and the RFT are directed, i.e. the subjects are informed about what kind of cues they are supposed to attend to. On the other hand, the instructions in the SAE-task are not directed. The aftereffect is presented in a neutral way and the subject is free to interpret for himself what kind of response is desired.

The analysis of individual behavior in these three situations confirms the main hypothesis that the ability to perceive the retinal stimulus is related to field-independent perception in RFT and to short initial duration of SAE, i.e. the mean of two first durations in the series of ten. The relation was more clear-cut in the case of RFT and the size-invariance situation, probably due to the greater similarities between these two tasks. However, a strong relationship to the size-invariance situation was evident when SAE-duration was combined with the results on RFT. The differentiation between low, high and intermediate SAE-durations showed that the two extremes in SAE-durations are of particular interest in this context. It may be concluded that individuals with short SAE-duration and field-independent RFT-performance show a higher ability to perceive in terms of the retinal object than do individuals with long SAE-duration and field-dependent perception on RFT.

Moreover, the results elucidate an interesting aspect of the interplay between executive and peripheral motives. It could be asked, for example, whether the strong interfering influence of physical-object-oriented perception shown by some individuals in the size-invariance situation is due to their exceptionally strong dependence upon reality. (In fact, they showed similar behavior in another version of the size-invariance situation where the task was to match objects for size on the basis of appearance). The relationship obtained between high interference of physical-reality oriented perception in the size-invariance task and long SAE-duration negates this interpretation, however. In contrast to the size-invariance situation, the interfering aspects of SAE (i.e., traces of previous stimulation) are not reality-adaptive. Instead, they have a distorting influence on reality perception. Consequently, it seems that it is not the reality-adaptive function per se which prevents the experiential shift in the size-invariance situation. Rather, underlying the interindividual differences seems to be a general ability to separate out interfering information irrespective of its content. Thus, the organizing factor here seems to be the formal ability to differentiate.

However interesting this finding appeared to be, the aim was not to simply make another contribution to the growing number of different cognitive styles. Having specified "what the subjects do" in a given situation, interest was shifted to the more general question of "why do they do it?" or in other words to the question of the origin of object perception.

II. Developmental aspects

The genetic method developed by Jean Piaget aims at exploring the psychological mechanisms in the process of their formation during ontogenetic development. The central question concerns the origin of objective knowledge. Object acquisition (in perception and intelligence) is a pivotal problem in this context and lies at the very heart of Piaget's theory. Piaget's main interest is not, however, in analyzing the entire spectrum of factors determining individual behavior in particular situations. Instead, he focuses on factors which have relevance for his ultimate interest in analyzing the conditions under which objective knowledge emerges. In studying perception he examines its epistemological status, particularly in comparison with that of operative intelligence.

In terms of Heider's model, Piaget refuses to accept the copy-theory of object-perception. Perceiving an object means for him not simply reading the sensory data. For a stimulus to become a psychologically meaningful object, or a thing, the subject must adapt to it in a twofold way: by assimilating the object into his organization and by accomodating his organization to the particular characteristics of the object. This adaptation presupposes an introduction of active schemes through which the assimilative - accomodative process works. As Piaget (1974) expresses it: "... I attempted to show that in every field (perception and association) in which the subject acquires some knowledge by reading experience, this reading does not consist of cumulative recordings but in assimilation, that is in incorporating the facts in organizing schemes, due not only to the subject's activities but equally to the object's characteristics".

However, according to Piaget (1969), it would be a mistake to think of perception as the primary source of veridical knowledge. Perception is a figurative aspect of knowledge and it reaches the object only as the latter is here and now. This means that perception

concerns the configurations or states of objects and events. In contrast, the operational aspect of knowledge is responsible for transformations of these configurations. These two aspects are conceived as basically indispensable for each other. However, Piaget argues that if perception is left to itself, it produces deformed information concerning reality (e.g. in optical illusions). These distortions are most pronounced in so-called field effects, where immediate interactions occur between elements perceived simultaneously in a single field of centration. On the other hand, effects of such single centrations are in part compensated by perceptual activities consisting of relating across spatial and temporal intervals.

Perceptual constancies are examples of such perceptual activities. The underlying mechanism in the case of size-constancy, for example, is that of compensation between the apparent (i.e. retinal) size and the distance (apparent size $\times$ distance = real size). Perceptual constancy thus appears to be a perceptual scheme of conservation similar to conservation of an operational nature, as for example in the classical task in which a clay ball is transformed into a sausage. Both in the case of perceptual constancy and that of intelligence, the compensations involved give rise to the invariances. There are great differences, however, between these two kinds of compensation, concerning both the final precision of the invariance achieved and the underlying structural mechanisms. While for intelligence the compensations are characterized by precise invariance (the matter contained in the sausage is exactly equal to that contained in the ball), perceptual compensations consist of approximative readjustments as reflected in underestimation or overestimation in size-invariance tasks. The precise invariance of intelligence is due to the reversibility of relations between the components, which is possible on the operational level. It is also only at the operational level that subjects show an intellectual comprehension of the process of compensation. This means that, for an explanation of perceptual constancies, one does not have to go beyond perception

itself, since elements of perceptual composition compensate for one another, not because of an understanding of the phenomenon but because the subject has experienced this unity while applying schemes of action.

Focusing on the general problems of how perception and intelligence are related, Piaget differentiates among different types of genetic relationship found between notions and the perception corresponding to them. First, notions and perceptions are divergent in their evolution. This is illustrated by empirical studies of developmental connections between projective notions (the understanding of the laws of perspective, as it appears, e.g., in children's drawing) and the ability to perceive in terms of the retinal object (as, for example, in the size-invariance situation). It has been shown that younger children perceive retinal size more accurately than older children, this ability deteriorating between ages 7 to 8 years and 10 to 11 years of age. Thereafter it improves again but never reaches the level observed earlier. On the other hand, the projective notions do not develop until 9 to 10 years of age. This means that, when projective perception is at its best (in young children), an understanding of it is not yet found. Moreover, the ability to perceive retinal size deteriorates at the time when projective notions are formed. These findings are interpreted as indicating a lack of developmental interdependence between perception and notions. Such findings are also used to support Piaget's major thesis that notions do not have their origin in perception. Instead, the development of notions requires the intervention of representational schemes based on coordination of different perspectives, i.e. including mobile transformations in contrast to perceptual configurations.

There are, on the other hand, certain developmental "affiliations" between perception and intelligence. For example, functional similarities between perceptual invariances and invariances of intelligence are found, as indicated above. These similarities con-

sist of a system of compensations which guarantee object-invariance while certain object-properties are changing. On this basis, a reciprocal relation is assumed to exist between the construction of the scheme of object permanence (a peak of sensory-motor intelligence indicated by the infant's search for a hidden object) and the chronologically preceding perceptual constancies. Various aspects of perceptual constancy (e.g. the compensation of retinal size and distance) favour the construction of the permanent object and prefigure it. Reciprocally, perceptual constancy gains from the construction of the permanent object. Here again, however, perceptual constancy cannot be seen as an origin of object permanence, which is the result instead of successive object displacements and their coordination, aspects which are beyond perception.

Even more indirect is the relationship between perceptual constancies and operational conservations (the conservation, e.g., of matter, volume, etc.), achieved at age 7 - 8 years. Of course, operational compensations are not abstracted from perceptual constancies. Instead they are reconstructions, on the operational level, of sensory-motor organization, and they are therefore connected with the scheme of the permanent object. Neither do the operational conservations seem to exhibit any substantial influence on perceptual constancies, a fact attributed to the long time interval of 7 - 8 years between the first appearance of perceptual constancies and the establishment of operational conservation. However, in other respects, the influence of intelligence on perception is clearly demonstrable.

Summarizing the point of view here, neither perceptual nor conceptual knowledge is a copy of something given in the external world. Instead the origins of knowledge are seen to lie in the subject's constructive activity. In this respect, there is only a difference of degree between perceptual structures and structures of intelligence. In the case of perception, activities there account for certain schematization and assimilation, resulting in structures which are

necessary for acquiring knowledge. On the other hand, such activities, when compared with the operational structures, play only a subordinate role in the process of attaining objective knowledge. Structurally, there is only partial isomorphism between structures of the two types. From a genetic point of view, the relationship found between perception and intelligence has its origin in their common sensory-motor basis during the first years in life. Later, the relationship consists of the influence of notions on perception in the form of certain enrichment and structuring.

Criticisms directed at Piaget's viewpoints are widely known. One important weakness is that he employed the developmental method in a much less consequent way when dealing with perception than in his work in other fields. In general, comparing the final products of perceptual and conceptual processes, he minimized their mutual inter-relatedness. Almost no effort was spent on the study of their continuous interplay. He does not make an empirical study of the processes involved; he makes a logical analysis aimed at finding differences.

Several studies of the relationship between perception and intelligence have been carried out at Lund University. These studies were undertaken within the broader context of investigations of visual aftereffects (Andersson, Nilsson, Ruuth & Smith, 1972). The way in which visual aftereffects are treated in this tradition is somewhat different from the usual one. Instead of studying visual aftereffects as a function of variation in the parameters of the stimulus and of the projection screen, aftereffects are used as method of studying personality and cognitive development. These studies demonstrate a clear interdependence of the subject's cognitive level (in Piaget's sense) and his perception of visual aftereffects (Ruuth & Smith, 1969, Andersson et al., 1969, Smith & Sjöholm, 1970, 1971a, 1971b).

Study II in the present series aimed at studying various aspects of the relations found between perception and intelligence in object-achievement during ontogenesis. For several reasons, the spiral aftereffect situation (described above) seemed particularly suitable for this purpose. First, the position of the aftereffect between the subjective world and the objective world provides a unique opportunity to study changes in the subject-object relationship and their effect upon object-achievement. Second, the aftereffect is a phenomenon unknown to children (as indeed to many adults), which means that its perception and understanding are free from previous exercise. Moreover, the SAE-situation provides a good opportunity for studying the aspects of intelligence and perception within one and the same task.

It was reasoned that development of the relationship between subject and object during ontogenesis should be reflected in the understanding of both the SAE-phenomenon and SAE-perception. In working with a similar problem, Piaget's intention was typically to demonstrate the shortcomings of perceptions and the superiority of intelligence. In contrast, the purpose here was to study the interrelation between the two. The basic theoretical assumptions, however, are consistent with Piaget's theory. These imply that developmental changes reflect an active and constructive process of differentiation between the subject and the object.

In Piaget's opinion, subject-object relations undergo substantial changes during ontogenesis. The following principles which Piaget (1969) formulates apply both to perception and intelligence:

- (1) objectivity is constructed on the basis of, and in proportion to, the subject's activities;
- (2) the initial state of each process provides not the properties of the object but an undifferentiated mixture consisting of contributions by the subject and the object alike;
- (3) it is by decentring himself from these initial states that the subject succeeds both in gaining control over his structures

through coordinating them, and in attaining the specific characteristics of the object through correcting deformations which his initial centrations produced.

Concretely, the development of an understanding of subject-object relations begins at the sensory-motor level, when the child can distinguish on a practical level between reality and his own actions toward it. However, a reconstruction of these relations on the representational level is required for a child to achieve an intellectual understanding of the relationship between reality and its appearance. It was hypothesized that children at age 7.5 - 8.5 years would differ in respect to their understanding of the apparent character of the SAE-phenomenon. This capacity to understand the SAE-phenomenon was expected to be related to the initial duration of the aftereffect. In line with Andersson (1971), extreme (short - long) durations were conceived to represent a less sharp and therefore developmentally lower differentiation between the subject and the object than do intermediate durations. More precisely, short durations were assumed to indicate an overvaluation of nonself-factors in perception, while long durations were assumed to reflect an overvaluation of self-factors.

Furthermore, SAE-understanding was expected to be related to the capacity for coordinating different points of view in Piaget's Coordination of Perspectives Test (CPT). In this well-known test, the child sits in front of a model representing a landscape with three mountains, his task being to differentiate between pictures showing the mountains from different perspectives. A young child is typically ignorant of the differences between his own point of view and that of others. Therefore, he ascribes his own perspective to persons looking at the mountains from another position, this reaction being the prototype of the egocentric behavior in children (Piaget & Inhelder, 1967). Underlying the expectations here was an assumption by Piaget of connections between representational object-achieve-

ment and the construction of representational space, both of these depending upon a general system of reference involving relations between things, as well as between the subject and the object.

The data confirmed the expectations. Children differed in their degree of understanding the SAE-phenomenon as real (i.e., conceived as a physical change in the external world) or subjective (i.e., apparent change). The level of understanding was shown to be related both to results on the CPT and to the perceived initial duration of the aftereffect. Children who understood the apparent character of the SAE performed better on the CPT. They also obtained more often intermediate than extreme SAE-durations.

These findings seem to indicate a process of development within both perception and thinking as regards subject-object relations. However, it is more difficult to answer the question concerning the kind of interrelatedness between the two. For Piaget, the relationship between initial SAE-duration and SAE-understanding would probably be a good example of the influence of intelligence on perception. This interpretation is supported by findings by Smith & Sjöholm (op.cit.) in epistemological studies of projected afterimages. The authors show that the perception of visual aftereffects can be manipulated through instructions which offer different "theories" about the nature of visual afterimages. Groups of children matched for cognitive maturity in the Piagetian sense differed significantly as to the size and color of projected afterimages, depending on the instructions given. "Adult" instructions described afterimages as subjective phenomena whereas "childish" instructions considered them as physical objects. The perception of afterimages could in fact be changed if the instructions were shifted during the experiment.

III. Toward an integration

Study II cast light on relations between perception and thinking within the context of a general development toward objectivity. Considered together with the results of Study I, it contributes to an understanding of the developmental origins of the effectiveness and veridicality of perception. On the other hand, there is still much left to be done concerning an understanding of the problem of object-perception as a whole, including both its developmental origins and the relation of these to adult behavior. In fact, this question leads to one of the central problems in modern psychology, namely that of an integration of the developmental and differential points of view. Study I focused on interindividual differences in adults, demonstrating the generality of the cognitive style of differentiation as it was reflected in three different situations. Concentrating on one of these situations, that of the SAE-phenomenon, Study II disclosed some of the ontogenetic developmental mechanisms relevant to the problem of object-achievement. It appears now that any attempt to integrate the developmental and differential foci has to account for the problems both of what happens to the psychological dimensions and of what happens to the individual (cf. below).

The major contemporary developmental theories focus typically on general ontogenetic changes in development and are relatively unconcerned with individual differences. For Piaget, for example, individuals can be classified as belonging to different stages, while the differences within a given stage (i.e. orthogonal to development) are not considered. In fact, Piaget is not at all interested in the individual subject as usually conceived of in psychology. Instead, he focuses on the epistemic subject, i.e. on that cognitive nucleus which is common to all subjects at a given level (Piaget, 1968). An exception to this general trend are efforts made to integrate the differential and developmental foci in the area of cognitive style. Perhaps the best example here is the work of Witkin and his associates (Witkin et al., 1954; Witkin et al.,

1962), who were interested in the problem of the origin of the cognitive-style dimension of differentiation. Their longitudinal studies attend both to ontogenetic changes in differentiation (i.e., the increasing ability to differentiate) and to individual differences in the ability to differentiate. Similar efforts can be found in the cognitive-style group at Menninger Clinic (Gardner & Moriarty, 1968). However, as Wohlwill (1973) points out, despite emphasis on differing aspects of the developmental-differential problem, there seems to be a basic confusion regarding the subject of study here. The confusion concerns the question of whether what is being dealt with are basically developmental dimensions on which individual differences are superimposed or instead dimensions concerning individual differences which are subject to certain age-related change.

Study III attempted to deal with the problem of what happens both to psychological dimensions and to the individual during ontogenetic development. For obvious reasons, studies with such aims call for longitudinal data. Consequently, two successive follow-ups of subjects who participated in Study II were carried out, each after a one-year interval. This involved the investigation of developmental changes in the duration of the spiral aftereffect, in the understanding of this phenomenon and also in results on the Coordination of Perspectives Test during the period of time between ages 8 and 10 years.

The data analysis shows that as concerns general ontogenetic changes in SAE-duration, there is a linear age trend indicating decreasing duration of the aftereffect between ages 8 - 10. This finding confirms expectations based on a cross-sectional study by Andersson et al., (1977). In that study, which included age levels 7, 9, 11, 13, and 15 years, a similar age trend was revealed for initial SAE-duration. On the other hand, a quartic trend was more appropriate for describing final SAE-durations, where long aftereffects reappeared

at 11 years of age.

Individual consistency in the sense of maintaining the position relative to others over the years was higher for final SAE-durations (mean value of two last trials in the series of ten) than for initial SAE-durations (ranges of correlation coefficients 0.28 - 0.39 and 0.13 - 0.21, respectively). Individual development was also studied by tracing patterns of individual change from year to year in respect to the categories short - long - intermediate SAE-duration. As expected, the understanding of the SAE-phenomenon increased with age, as did the ability to coordinate perspectives. However, the relationship previously shown at age 8 between the understanding of the SAE-phenomenon and the results on the Coordination of Perspectives Test was not found here for ages 9 and 10. In fact, the comparison at age 10 became meaningless since interindividual variation on the CPT almost vanished. Neither did the relationship found at age 8 years between the level of thinking and SAE-perception appear at ages 9 and 10 years.

Returning now to the problem of the integration of the differential and developmental points of view, the dimension of differentiation between the self-nonsel self factors in perception (assumed to be measured in the SAE-situation) shares the advantages of the differentiation dimension as used by Witkin and, of course, also by Lewin and Werner. The main point is that the inherent generality of the differentiation dimension makes it suitable for unifying both the developmental data and data on individual differences.

This characteristic of the differentiation dimension plays a central role in Andersson's approach to the developmental-differential problem (Andersson, 1977). The ontogenetic changes in the perception of the SAE are assumed to reflect a change in an individual's differentiation between himself and his environment. The direction of this change is from a less differentiated to a more differentiated mode of

perceiving, where a less differentiated mode is expressed through an overemphasizing of either the non-self pole (leading to short durations) or the self pole (which leads to long durations). The empirical findings with children in early childhood (4 - 6 years of age) support the idea of an ontogenetic developmental trend of the sequence short initial durations - long durations - intermediate durations. Further empirical evidence concerning later ages was presented above. The empirically grounded paradigm of short - long - intermediate SAE-durations is generalized to become part of a model attempting to embrace cognitive development as a whole. Underlying this theoretical model is the idea of a dialectic principle steering the interaction between different cognitive action systems from an initial ontogenetic stage of tropistic-reflex reactions to stimuli via sensorimotor action upon signaled things and perceptual-figural regulation to the stage of conceptual-operational transformation, and finally to hypothetical construction. The impetus for change through the hierarchy of stages is inherent to the dialectic triad consisting of thesis - antithesis - synthesis. A new action system (e.g., the conceptual-operational) springs from an antithesis to a developmentally lower one (in this case the sensorimotor). Of central importance is the fact that, in respect to differentiation, the synthesis achieved changes qualitatively at each stage which is reached. At the sensorimotor stage of synthesis the infant can differentiate between reality and his own actions toward it; at the perceptual-figural the child can distinguish between reality and its appearance; finally, the ability to differentiate between reality and own thought about that reality indicates the achievement of the conceptual-operational synthesis. This provides the possibility for hypothetical construction, an action system that in the model is open-ended.

According to this view, the differential perspective is relevant for describing changes occurring after a given endpoint of synthesis has been reached. These changes are assumed to reflect personality

differences and are understood using ontogenetic development as a frame of reference. Thus, short or long final (stabilized) SAE durations, achieved by adults toward the end of a series of 10 SAE trials, represent less sharp differentiation between self and non-self factors (within the perceptual-figural action system). In contrast, optimal differentiation between these factors is shown by intermediate durations. The association in children between the initial SAE duration and the level of cognitive development thus finds its parallel in adults in the association between the final SAE duration and personality (social-emotional) functioning (Andersson & Weikert, 1974). More specifically, the final SAE duration is assumed to reflect the individual's unique and preferred relationship to the environment at a given period of life. This relationship, which the SAE-experiment demands the individual to reconstruct, is referred to as his identity. To summarize, it appears that the basis for the integration of the differential and developmental perspectives is the ordering of individual (personality) data in adults along a dimension which has a some formal similarity (in Werner's sense) to ontogenetic development.

A methodologically oriented approach to developmental-differential problems can be found in Wohlwill (1973). He attempts to define the subject of study and to elucidate the methods employed in various approaches to this problem. Basically, he differentiates between two foci in the study of individual differences in development. These foci will be referred to below and illustrated with examples from the area of SAE-perception.

(1) Focus on differential aspects of developmental change.

An approach centered on differential aspects of development presupposes the existence of developmental psychology which unlike the classical one focuses on developmental changes rather than on developmental differences. For example, instead of studying whether the differences between means in groups of different age levels are

significant, it would be focused on the shape of the curve formed by these means. Thus, outcomes of the study of behavioral change would be developmental functions describing the form of the relation between chronological age and the changes observed to occur on some specified dimension of behavior during the course of development. According to Wohlwill, this approach would solve the problem of integrating the differential with developmental aspects of behavior since it would be possible to express differences among individuals in terms of the quantitative parameters or qualitative characteristics of the developmental function for certain variables. By this means, the differential approach would be assimilated into the developmental one. For example, in the area of SAE-perception studies, one could be interested in individual variation around the general developmental function. As will be recalled, a linear age trend indicating decreasing SAE-duration was found to characterize development at ages 7 - 10 years. It could be meaningful to analyze individual variation around this general developmental function. In terms of Fig. 2, it appears that the general decrease in SAE-duration may in fact take different routes for different individuals. This information can be used either for purely descriptive purposes, i.e. to identify salient aspects of a given child's development, or to relate to other information about individuals or groups.

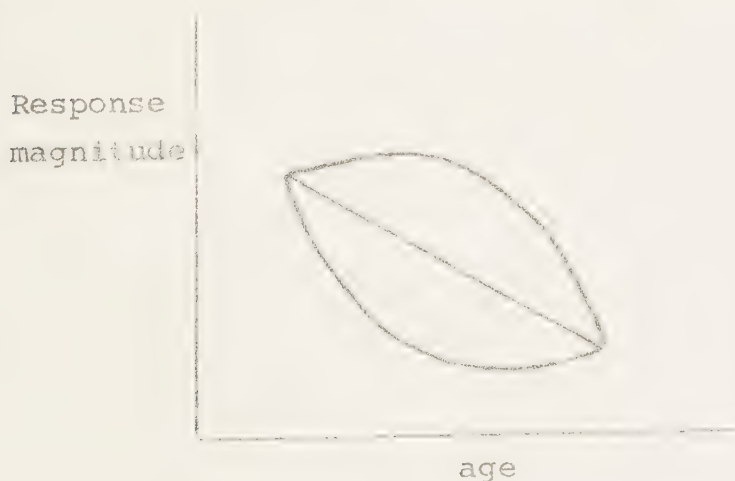


Fig. 2. Schematic representation of individuation based on differences in the form of developmental functions.

(2) Focus on developmental aspects of individual differences.

Focusing on developmental aspects of individual differences, the interest shifts from developmental functions to the origin and developmental course of individual differences. Topics which would be explored here are the problem of the differentiation of psychological abilities, the emergence of traits, the transformation of dimensions or interindividual differences over age, etc. In contrast to the focus on differential aspects of developmental change, the present approach does not presuppose any systematic age changes to occur on the dimension of interest. That is, differences among individuals are analyzed independently of level. Wohlwill presents a classificatory scheme of major problems in this field, the three classificatory principles being whether the focus is one the individual or the psychological dimension, on a univariate or multivariate approach, and on developmental change in individual differences or on their stability. His scheme (modified here, however, to combine the focuses of stability and change) is shown in Table 1.

Focus on	Single-variable case	Multivariate case
The individual	(a) Individual patterns of change in z-scores and similar measures. Invariance of z-scores or other relativized measures at different ages.	(b) Changes and constancy of patterns of ipsative relationships among variables.
The dimension	(c) Patterns of change in variability. Stability of individual differences for a variable across a time interval.	(d) Changes and constancy in factorial structure across age. Emergence of factors and their developmental transformation.

Table 1. Topics in the developmental study of individual differences (adapted from Wohlwill, 1973).

(a) The developmental history of individual differences along a single variable.

In studying the developmental history of individual differences in a given variable, the aim is to describe the route by which an individual arrives at a particular point in development. The individual patterns of change demonstrated in Study III can serve as an illustration. Thus it was possible to trace changes in an individual in his belonging to the categories of short - medium - long SAE-duration at three occasions in his ontogenetic development. For example, one such individual route began with a short SAE-duration at the first test occasion, followed by a medium duration the next year and a short duration finally the third year. Different routes of this sort can be compared, e.g. in terms of stability. However, as Wohlwill points out, the value of such developmental profiles in relation to problems of personality remains to be established; no adequate investigation has been carried out as yet. On the other hand, studies relating individual patterns of change to adult behavior could be of considerable interest. It could be asked, for example, whether systematic differences are found between adults who, though all showing short SAE-durations, arrived at this level by different routes. One such route might be characterized by continued change and involve long durations part of the time, whereas another might be highly stable throughout development. It is reasonable to expect that an approach of this sort would promote more profound understanding of the meaning of adult behavior in the SAE-situation.

(b) The developmental history of patterns of ipsative relations within a set of variables.

In the multivariate equivalent of the approach just described it is possible to study changes not only within one variable but also among a set of variables, the individual still being the point of reference. Although an ipsative analysis has a definite place within various fields, within personality (e.g. Allport, 1962) and social

psychology (Heider, 1958), for example, a systematic developmental approach is still lacking. As Emmerich (1968) points out, this is particularly surprising when we consider the fact that such influential developmental principles as Werner's orthogenetic principle (Werner, 1957) is well suited to an ipsative analysis since it refers to developmental processes of differentiation and hierarchical organization within intraindividual structures. Thus, the ipsative approach could be fruitful when dealing with the question of structural "reorganization" (i.e. qualitative change in methods of regulation) as this is assumed to occur in Andersson's model of cognitive development. With a given individual, one could attempt to determine what the organizers of restructuralization are, considering this in terms of a specified set of variables. Furthermore, one could study the generality of this change, e.g. in the sense of how many different attributes are involved in the individual's repertoire. A question may arise regarding the purpose of such focusing on one particular individual. In this context, the concept of identity in the sense of an individual's unique relationship to the environment at a given period of life, which is included in Andersson's conception, should be borne in mind. It seems that an ipsative analysis is inevitable if uniqueness is to be accounted for, even if this approach does not exclude a parallel construction of systems consisting of a manageable set of prototype "identities". The discussion of the idiographic versus the nomothetic approach within the clinical situation may be relevant here.

(c) Focus on a dimension - the study of age changes in individual differences with respect to a single variable.

The question may arise of changes in a given dimension regarding its variability over age. It could be expected, for example, that intersubject variability might progressively increase at some point during ontogenetic development (representing the emergence of a dimension of individual differences) and vanish at some other point. In the case of SAE, an increase in the intersubject variability of a

given variable might accompany periods of "restructuralization" as they appear in Andersson's model of cognitive development. On the other hand, when new methods of regulation are integrated within the individual, a certain period of consolidation might follow, leading to diminished interindividual variability. As regards the stability aspects, the correlation between two measures taken at two different occasions is the measure most frequently employed. It will be recalled that in Study III a higher tendency for stability was found in terms of final SAE-durations than of initial durations.

(d) Focus on dimensions - multivariate study of age changes in individual differences.

Previous examples have shown that changes of individual differences in single measures can profitably be studied. However, critical voices have questioned the adequacy of such research for the study of complex multidimensional psychological constructs (such as differentiation). More specifically, such investigation may run the risk of neglecting complex interrelationships among behavioral systems and of presenting a fragmented picture of development. In contrast, the multivariate approach offers the possibility of dealing with the changing patterns of complex interrelationships among different variables. Programs for such research have been described by Emmerich (1964) and by Baltes & Nesselroad (1973), both working within factor-analytic approach. Interest is focused on topics such as the comparison of factorial structures at different ages, the emergence and disappearance of factors, changes in their mutual constellation or changes in their meaning. The continuity and the stability of dimensions during ontogenetic development is analyzed, continuity here referring to the identity of the structural relationships among a set of variables and stability referring to the preservation of individual differences from one occasion to the next. Concretely, the study of the patterns of change in the factorial network could provide a tool to deal with questions which arose in Study III and elsewhere, the identity of the differentiation

dimension in general (and of the SAE-duration variable in particular) during ontogenesis, the differences in meaning of initial and final SAE-durations, and finally the origin and "fate" of individual differences.

C o n c l u d i n g r e m a r k s

It appears that object-perception is a classical issue which cuts across the major areas of psychology. The intention here has been to emphasize not only the central nature of this problem for psychology, but also its multidimensional character. It can be hoped that in future research the treatment of object-perception will not take the form of a simple accumulation of different "points of view", depending upon the area involved. Instead, further integration seems needed. Even if this appears difficult - or according to some views virtually impossible - in a branch of science so typically split as psychology, it seems clear that integration in this context has to proceed along two lines: methodological and theoretical. As concerns theoretical aspects, some convergence can be shown between the two main approaches discussed here. As was seen, In Piaget's system the structural equipment of the individual enters into object-achievement as an intervening variable, meaning that the latter cannot be conceived of as an object-copying process. In the same vein, the cognitive-style approach does not conceive of object-achievement as being driven exclusively by needs, since here too the structural equipment of the individual enters in as an intervening variable. However, it seems that if the ultimate aim of integration is to capture the wholeness of the human being within the totality of its existence, then a study of how the individual functions in relation to external object must be complemented by a study of the individual's functioning in relation to its internal counterpart, i.e. to needs (cf. Nilsson, 1977).

A c k n o w l e d g e m e n t s

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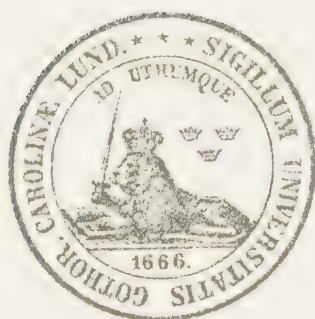
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*Perception in Size-Invariance Situations as Related
to Visual Aftereffect Perception and
Rod-and-Frame-Test Performance*

by Jitka Lindén



LUND UNIVERSITY SWEDEN

A b s t r a c t . - Studied "analytic" and "apparent" size-invariance situations in 56 university students aged 19 - 51 years (age mean=23). As predicted, ability at perceiving retinal size in an "analytic" situation was related to short spiral aftereffect duration in the initial trials in a series of ten, and to field-independent perception in the Rod-and-Frame-Test. A relationship between physical-object-dependent perception in the two size-invariance situation was also found.

I n t r o d u c t i o n

It is a common observation that things appear of about the same size when placed at different distances from the observer, despite marked differences in the size of the retinal image. This size-invariance (or size-constancy) phenomenon has been investigated throughout the history of psychology. It concerns not only a crucial epistemological problem in perception - the relation between the perceptual experience of an object (its phenomenal size) and its physical properties (its metric size) - but it is also readily amenable to experimental study.

Size-invariance has been investigated within various theoretical frameworks, although mainly within a psychophysical one (for a review see Baird, 1970). An assumption basic to the latter approach is that an experienced quality can be traced to a specific proximal stimulus. Consequently, investigations here have aimed largely at determining the stimulus adequate for experiencing size-constancy. According to Gibson (1959), such a stimulus can be defined by invariant relations between certain conditions in the retina, this proximal invariance representing both a necessary and a sufficient condition for experiencing size-invariance. Thus, size-constancy is only a specific case of a general mechanism underlying the veridicality and efficiency of perception, the perceptual experience of an object reflecting the relations in the retina.

In contrast, in quite a different theoretical context, that of

the "New look movement", the decisive role in perception was assigned, not to the proximal stimulus, but to internal factors such as motives and personality traits. This approach emphasized the reality-distorting effect of such internal factors, where the inconsistencies in the size-constancy were seen as demonstrations of the susceptibility of perceptual experience to the influences of such factors (e.g. Bruner and Postman, 1947).

Klein (1970) endeavored to unite these two approaches on the basis of a thorough analysis of the components in the perceptual process as a whole. Distinguishing between thing and medium (Heider, 1959), he maintained that physical invariants (which have the status of potential stimuli) can be interchangeably mediated by different mediating patterns. Information registered on the primary level (retinal information) can result, under different motivational conditions, in the perception of different thing-qualities. In other words, the perceptual experience of an object requires the organism's active and selective participation in the perceptual process. This involves the coordination of personal intentions with functionally relevant properties of things. According to Klein, perceptual selectivity here cannot be explained within a psychophysical framework, the veridicality demonstrated there being largely due to a special motivational "reduction screen" characteristic of psychophysical studies. He saw the experimental setting in such studies as promoting "executive intentions" (i.e. reality-oriented motivation concerned with the mastery and control of objects), whereas under various conditions, perceptual experience might be influenced by the arousal of more peripheral (i.e. contextually nonadaptive) motives.

Such a view does not suggest, however, that perception is at the mercy of every motive activated. In most instances, perceptual structures guarantee effective coordination with environmental regularities. It is mainly the coded properties relevant to purposeful action which would presumably be experienced, the subject

not being aware of other qualities having more subsidiary status. This is evident in perceptual constancy, where repeated contact with invariance in the real world results in an effective coordination of action, perceptual experience and object structure. Since the object-properties aimed at in everyday life are physical invariants, these can be expected to be the focus of awareness. Retinal size, on the other hand, has only a mediational role in reality-oriented perception and is presumably beyond awareness.

The aim of the present study was to explore certain factors underlying the process leading to perceptual experience, particularly those involving an interplay between "executive" and peripheral motives. In previous studies of similar purpose a common method has been that of enhancing more peripheral motives by confronting the subject with equivocal, impoverished or conflict-laden stimuli. In contrast, the method used here demands a shift in the subject's experiential emphasis. More precisely, interest is centered on individual differences presumably revealed when the subject copes with a task demanding that the usual physical-invariance oriented type perception be relinquished. Experiential emphasis is placed instead on retinal object-properties of which the subject is usually not aware. Of primary concern, therefore, is not the distortion of realistic perception by peripheral motivation but rather the effect which ordinarily dominant intention, temporarily made peripheral, has upon perception. An additional aim is to investigate this particular aspect of perceptual experience further, analyzing its relations with behavior in a different size-invariance task, as well as in a visual aftereffect situation and the Rod-and-Frame-Test.

Perceptual attitudes in size-constancy situations

There are several kinds of perceptual attitude which can be held by a perceiver in size-matching tasks under conditions of free binocular observation (i.e. in the presence of adequate cues of depth):

- (1) A synthetic or objective attitude, present when the subject's task is to match the physical size of the objects under consideration;
- (2) An analytic attitude, found when the task is that of comparing the areas of space projected at a given distance by the two different stimulus objects (i.e. to judge this in terms of visual angle or retinal images);
- (3) An apparent-object attitude, present when it is the subject's task to match objects on the basis of how they appear, without taking the laws of perspective into consideration.

In general, judgments made when the first attitude prevails tend to approximate the physical size of the objects compared, whereas judgments made under the influence of the second and third attitudes tend to be intermediate in size between the physical and retinal sizes of the objects. The tendency to be influenced by physical size even when adopting an analytic attitude was described by Thouless (1931) as "phenomenal regression to the real object". However, individual differences were shown to be great, ranging from "overconstancy" (i.e. "overshooting the mark" in the physical object direction) to almost perfect retinal matches.

In the present study, two different situations were employed. These were aimed at arousing different attitudes.

- (1) Apparent-object-equality situation (SC₁). Here the subject's task was to match two circles for size while adopting the apparent-object attitude. It was assumed that the object-equality experienced in this situation is based on a perceptual as compared with a conceptual type of object-equality, where in the latter case conscious application of laws of perspective occurs. The difference between the perceptual and the conceptual attitudes here can be illustrated

by the following comment given by a subject who adopted an "apparent" attitude: "now the objects seem as if they were the same size ... but they are not really the same, since they are at different distances, which means that the object farther away is bigger". The aim in the present study was to elicit the manner of experiencing represented in the first part of the sentence. It was felt that a subjective, non-directed type of task would lead subjects to display personal solutions rather than common laws and beliefs. Of interest here were relations between the "apparent" situation and the "analytic" situation. In order to ascertain the degree to which a subject had succeeded in giving an apparent-object response, a short interview was carried out afterwards.

- (2) Retinal-equality situation (SC_2). In this task the aim was to determine a subject's retinal-object equality. The instructions were designed to elicit an "analytic" attitude. In contrast with SC_1 -situation (where physical and retinal sizes were varied), physical size was constant while distance and retinal size were varied. This was to diminish the advantage which the sophisticated subjects might have had in understanding the instructions, where it is easier to attend to retinal size if it is not linked with a physical size-change. In adopting the "analytic" attitude subjects were required to give perceptual prominence to properties which usually have only a mediational role in perception. Thus, the response to this situation represents a solution to a conflict between a set induced by instruction (that subjects follow retinal size-increase) and the usual attitude of orientation to physical reality.

The SC_1 - and SC_2 -tasks were given 10 times in succession in order to explore changes over trials. The direction of possible change was of particular interest. It was asked whether confrontation with the tasks would produce physical or retinal size-equality.

Size-constancy and spiral aftereffect duration

Visual aftereffects have a special place in perception. Phenomenologically, they can become objects of perception but are usually differentiated from percepts of real things. Adult subjects experience visual aftereffects as their own products but still perceive them as being within the realm of real things. It has been shown (Andersson, Nilsson, Ruuth and Smith, 1972) that this position of visual aftereffects between the subjective and objective worlds makes them useful in personality exploration. In the case of the spiral aftereffect (SAE) technique used here, the standard test procedure consists of registering the duration of the motion aftereffect during ten repeated trials.

There is a phenomenological similarity between the perception of SAE and the perception of retinal size in the SC₂-task. Both are perceptual phenomena which can be perceived, although they do not fit easily into the framework of realistic everyday perception. In both cases, subjects perceive a size-increase which cannot be attributed to the metric size-increase of perceived objects. In the SC₂-situation, the subject encounters the stimulus with a set formed under previous lifelong experience with physical objects; his task is to make this set peripheral and adjust perceptual experience to the instructions. In the SAE-situation the subject must find a state of equilibrium between the influence of an "experimental" set (induced by previous intensive stimulation) and the actual stimulus.

It was assumed that individuals differ with respect to the degree to which they can abandon an already established set or mode of functioning. It was reasoned that individuals showing a tendency to suppress SAE-duration would show a similar suppressive tendency in the SC₂-situation. This should result in a short aftereffect duration being linked with a good ability to perceive the retinal stimulus. The relation was assumed to be revealed more clearly in the beginning of the adaptive process, while the stimulus still possesses a certain degree of novelty,

as compared to the stabilized levels when adaptation to the stimulus has been achieved.

Size-constancy and field-(in)dependent perception

According to the differentiation hypothesis (Witkin, 1962), individuals differ in their ability to perceive their environment in either a global or an analytic fashion. Performance on the Rod-and-Frame-Test (RFT) has been used as a measure of the personality-construct of psychological differentiation, which is assumed to underlie this ability at organizing and relating to environmental events. Individuals whose perception is field-dependent (FD) are considerably influenced by the perceptual context, in contrast to field-independent (FI) individuals, who are able to perceive part of the field as being discrete from the rest. Consequently, if so instructed, FI-individuals can adjust the rod to be more or less in accord with the true perpendicular, independent of the frame position, as compared with FD-individuals, who are more influenced by the frame.

Individual differences on RFT have been related to many aspects of human functioning. The relation to perceptual constancy has been reported by Witkin et al. (1954). His results suggest that under the "apparent" instructions field-dependency in males is associated with a higher degree of brightness constancy. It could be reasoned that a similar relation would be found between RFT-performance and behavior in the "analytic" size-constancy situation. In both the RFT and the SC₂-situation, there are conflicting cues, subjects being required to pay attention to just some of them. In the SC₂-task some cues indicate the physical object and others the retinal object; in the RFT there are visual and proprioceptive cues in opposition to one another. Assuming that individuals differ in their ability to keep conflicting cues apart, one could expect field-dependency to be related to difficulties in attending to the retinal stimulus. FI-individuals on the other hand, could be expected to control the perceptual experience in accordance with instructions and to keep compelling

physical-object oriented cues out of the focal field. This would lead to a greater ability to consider the retinal stimulus.

In contrast with the usual RFT-procedure, deviations to the left of the true vertical were not treated as equivalent to deviations to the right, i.e. in the direction of the frame. Previously it has been suggested (Andersson and Ruuth, 1971) that deviations to the left may be interpreted as overcompensations for the influence of the frame. Therefore, these deviations were assigned negative values in our study. Consequently, individuals with equal deviations to the left and right of the true upright during repeated trials were considered less field-dependent than individuals with consistent deviations in the direction of the frame. Large negative deviations were not expected to occur often, since preliminary studies with similar groups of individuals showed the majority of negative deviations to be small. In any case, extreme negative deviations would deserve special attention. It was felt that the difference between these and extreme deviations to the right would be crucial. Even if the absolute error were the same in both cases, the process behind the two responses would be different, overcompensation appearing as an indicator of the subject's active attempt to overcome the influence of the frame. On this basis, it was expected that subjects with extreme deviations in frame-direction would show a poor ability to perceive retinal size whereas overcompensating subjects with marked negative deviations would possess a good ability to attend to the retinal stimulus in the SC₂-situation.

Method

Subjects

The subjects were 33 female and 23 male students from an introductory course in psychology, with an average age of 23 years (range 19 to 51 years). Subjects were paid for participation.

Size-constancy apparatus and technique

A semi-transparent screen (100×100 cm) was mounted at the smaller end of a table (300×40 cm). A disc (diameter 16.6 cm) could be moved (4.7 cm/sec) along the table on a rail system driven by an electric motor. The disc was made of cardboard covered with reflecting foil. A variable circle of light could be projected onto the screen from behind by means of a projector equipped with a diaphragm movable via an electric motor. The diameter of the projected circle was registered automatically and could be varied by the subject (within a range of 4 to 25.2 cm). The subject was seated on an adjustable chair in front of the screen (distance 380 cm) with his head in a fixed position. Thus, he saw two circles, the standard disc to the left and the variable light-circle to the right, both illuminated by a projector placed behind the subject. The brightness of the two stimuli was adjusted by means of a light-filter to be approximately the same.

SC₁-situation: The standard disc was kept at a constant distance 250 cm from the subject. The following instructions were given:

There are two circles in front of you. Imagine that they are two balls. By pushing this button you can make one of them bigger. You can also make it smaller with the same button. Try it for yourself! Your task will be to enlarge the ball until you think that it looks as if it is the same size as the other ball. We will do the same thing many times. Say "now" when you find the appropriate size.

The subject received 10 consecutive trials; the light circle having a diameter of 4 cm at the start of each. After all of these had been completed, a short semi-structured interview followed. The subject was asked what he believed the actual physical sizes were, how much he knew about laws of perspective, and how much difficulty he had experienced in the task.

SC₂-situation: This part of the experiment started immediately after SC₁. Here the projected circle was held constant (diameter 25.2 cm) while the movable target was put at the same distance (380 cm) from the subject so that the difference in sizes could

be clearly seen. The following instructions were given:

Now we will do another thing. You see one large and one small circle in front of you. If you push this button, the smaller circle starts to move. You perhaps can see that it looks as if the circle grows in size while moving. Your task will be to push the button until you think that the movable circle looks as if it is the same size as the circle on the screen. Do not try to reckon the size but try instead to concentrate on the apparent growth or increase.

For description of individual responses in the SC₁- and SC₂-situations, parameters previously used for the description of SAE duration patterns seemed appropriate: initial level (il) = $(d_1 + d_2)/2$, mean level (ml) = $(d_1 + d_2 + \dots + d_{10})/10$, final level (fl) = $(d_9 + d_{10})/2$, and an expression of linear regression describing the change over ten trials $(R) = 4.5d_1 + 3.5d_9 + 2.5d_8 + 1.5d_7 + 0.5d_6 - (0.5d_5 + 1.5d_4 + 2.5d_3 + 3.5d_2 + 4.5d_1)$, where d_1, d_2 , etc. denote diameter of the variable circle in SC₁ and distance of the disc from the subject in SC₂.

Spiral aftereffect technique

The apparatus was the same as used by Andersson, Nilsson and Henriksson (1970). The SAE was induced by means of a rotating, arithmetic spiral which appeared to the subject to be contracting. Immediately after the spiral had been shown, a circle was presented in the subject's field of vision. The subject perceived the circle as apparently expanding or moving toward him. He was instructed to say "stop" when the aftereffect on the circle ceased. There was one demonstration trial and one pre-trial. The main test consisted of ten massed trials, each with an inspection period of the spiral lasting 45 sec. The reported duration of the aftereffect which followed was registered by the experimenter. The usual way of describing individual SAE duration pattern was applied (see under SC-technique). However, because of the prediction made here, data analysis was chiefly restricted to the first two trials (initial level).

Rod-and-Frame-Test

A luminous square frame (78 cm side, 1 cm wide) tilting 20° to

the right appeared on a black background. Pivoted at the frame's center was a luminous rod (80 cm long, 1 cm wide) which could be tilted independently of the frame. The subject was provided with a two-way switch by which the rod could be moved to the left or right. He was instructed to adjust rod to the upright without paing attention to the frame. There were three pre-trials, the first under illumination, with the rod in a starting position of 20° to the left. Thereafter the room was darkened and the subject carried out the second pre-trial with the rod tilted 20° to the right and third pre-trial with the rod tilted 20° to the left. Between trials the subject turned around and shut his eyes, while the experimenter recorded the tilt and adjusted the rod to the starting positions.

The RFT deviation scores were determined with objective verticality as a reference point. Deviations (in degrees) to the right were assigned positive values and deviations to the left negative values. Data analysis was based on the mean deviation of the 12 main scores.

R e s u l t s

Relations between sex and all the SC_1 -, SC_2 -, SAE- and RFT-variables were assessed by means of point-biserial correlation. Since none of the correlation coefficients were significant below a 25% level (two-tailed test), male and female subjects were considered as one group.

Size-constancy situations

(a) Most subjects found the SC_1 -situation to be easier than the SC_2 -situation. According to their verbal reports, the reason for this was the "reality" of the metric change as compared with the apparent character of the retinal size-change. After the 10th SC_1 -trial (while still looking at the setting), subjects were asked about the metric sizes of the circles. The majority of the subjects found the comparison-circle larger than the standard. Fig. 1 shows the distribution of mean responses in the SC_1 -situation.

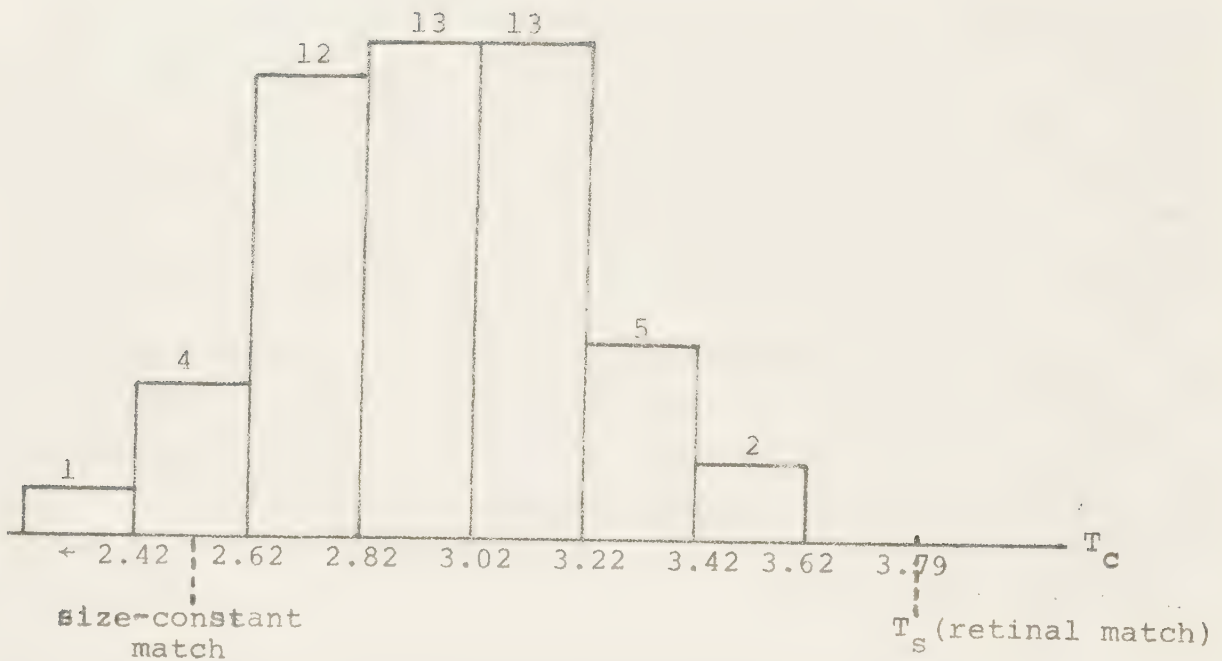
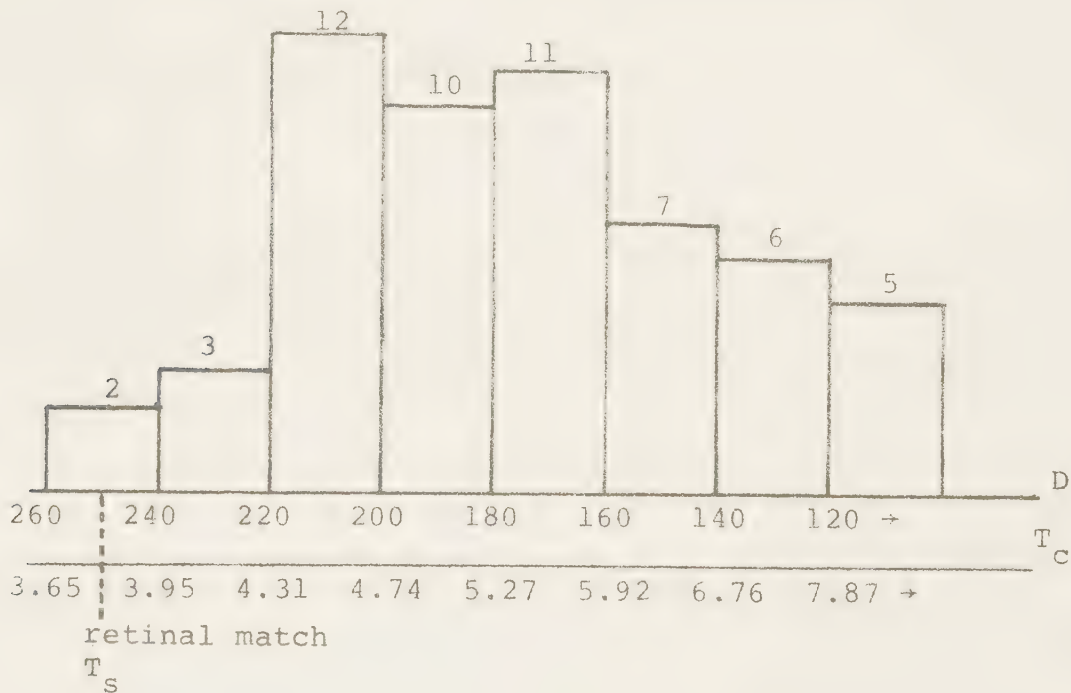


Fig. 1. Distribution of mean responses (ml) in SC_1 -test.



T = size of comparison circle in angular units
 T_c = size of standard circle in angular units
 D = distance in centimeters between subject and comparison target

Fig. 2. Distribution of initial responses (il) in SC_2 -test.

(b) There was great variation between individuals in the SC₂-task. Some subjects could see the apparent growth of the movable circle quite early and continuously (as apparent in their reports) and their subjectively experienced equality was quite close to true retinal equality. On the other hand, some subjects were very disturbed by the interference between their usual reality-oriented approach and the present task. They let the circle come very near, experiencing the increase only in the last stage if at all. Fig.2 shows the distribution of initial responses in the SC₂-task.

Table 1. Correlations between SC₁- and SC₂-variables.

Variable	SC ₂ _{il}	SC ₂ _{ml}	SC ₂ _{fl}	SC ₂ _R
SC _{1il}	-.18 N = 50	-.27 N = 47 P=.068	-.34 N = 47 P=.018	-.31 N = 47 P=.032
SC _{1ml}	-.28 N = 50 P=.046	-.35 N = 47 P=.018	-.38 N = 47 P=.008	-.19 N = 47
SC _{1fl}	-.27 N = 50 P=.062	-.29 N = 47 P=.046	-.31 N = 47 P=.032	-.15 N = 47
SC _{1R}	-.10 N = 50	-.02 N = 47	-.01 N = 47	.14 N = 47

Note: P-values refer to two-tailed tests. The R-variables were dichotomized (R<0, R>0). The coefficients refer to Spearman rank coefficients, point-biserial coefficients (level related to R) and phi coefficients (relation between R). N varies due to the exclusion of subjects for the following reasons: 4 persons because of clearly having had a physical-object approach in SC₁, 2 persons because of difficulties with the apparatus in SC₁ and 4 persons because of not completing all 10 trials in SC₂.

(c) It can be seen in Table 1 that there was a negative relation between most variables in the SC₁- and SC₂-situations. Individuals with physical object-dependent matches under the "apparent" instructions tended to be influenced by physical size even under "analytic" instructions and consequently to be less prone to perceiving in terms of the retinal object. Further, there was a

slight relationship between SC_{1il} and linear regression in the SC_2 -task. Thus, initially size-constant responses in SC_1 were related to a linear development towards less retinal matches over the ten trials in SC_2 . There was no such relation between SC_2 -levels and linear regression in SC_1 .

Relation between SC_2 and SAE

Table 2 shows relations between initial level in SAE and results of the SC_2 -test. As predicted, individuals with retinal matches in SC_{2il} tended to have short initial aftereffect duration in SAE.

Table 2. Spearman rank coefficients between SC_2 and initial duration of SAE.

Variable	SC_{2il}	SC_{2ml}	SC_{2fl}
	.23	.20	.16
SAE_{il}	N= 56 P=.04	N= 52 P=.08	N= 52 P=.13

Note: P-values refer to a one-tailed test.

Relation between SC_2 and RFT

As expected, individuals with retinal matches under "analytic" instructions tended to be more field-independent, i.e. to be less influenced by the frame in the RFT. (Table 3). Thirteen persons adjusted the rod to the left of the true vertical, i.e. in the direction opposite to the frame. Ten of these individuals were in the retinal group (i.e. below the median) in the SC_2 task. Only two individuals had a large negative deviation (above the median in absolute value-distribution), one of them with $RFT_{ml} = -2.71$ and other with $RFT_{ml} = -4.21$. Both of them were in the retinal group in the SC_2 -test.

Relation between SC_{2fl} and RFT_{ml} combined with SAE_{il}

The results of SAE_{il} and RFT_{ml} were combined in order to ex-

plore the relation between the combined groups and SC_2 . It was found that individuals who were both field-independent and had short or intermediate SAE_{il} -duration tended to perceive the retinal object better than did field-dependent individuals with long or intermediate SAE_{il} -duration. This relation is shown in Table 4.

Table 3. Spearman rank coefficients of correlation between RFT_{ml} and SC_2 -variables.

Variables	SC_{2il}	SC_{2ml}	SC_{2fl}
	.37	.33	.34
RFT_{ml}	N = 55 P=.002	N = 55 P=.008	N = 55 P=.008

Note: P-values refer to a one-tailed test.

Table 4. Relation between SC_{2il} and RFT_{ml} combined with SAE_{il} .

Group	SC_{2il} -low	SC_{2il} -high
SAE_{il} low and RFT_{ml} low	8	0
	} 15	} 5
SAE_{il} interm. and RFT_{ml} low	7	5
SAE_{il} low and RFT_{ml} high	3	3
	} 6	} 8
SAE_{il} high and RFT_{ml} low	3	5
SAE_{il} interm. and RFT_{ml} high	6	10
	} 7	} 15
SAE_{il} high and RFT_{ml} high	1	5

Note: $\chi^2 = 15.1$ df = 2, $P < .001$ (two-tailed test). The low and high groups on the SAE variable were defined in terms of the upper and lower quartiles ($SAE \leq 7.0$ sec and $SAE \geq 18.5$ sec, respectively). The high and low groups on SC_{2il} and RFT_{ml} were defined by a median-split.

Other comparisons

In addition to the interrelations mentioned above, all other possible coefficients of correlation (r_s) between SC_1 (il, ml, fl, R), SC_2 (il, ml, fl, R) SAE (il, ml, fl, R) and RFT (ml) variables were computed. None of them was significant at the 5% level (two-tailed test).

D i s c u s s i o n

The results obtained confirm the main hypothesis here that the ability to perceive the retinal stimulus is related to field-independent perception in the RFT and to short initial SAE duration. The relation was more clear-cut in the case of RFT and SC_2 . It seems that these two situations have more in common than SAE and SC_2 . First, the instructions in these two situations have a directed character which means that the subject is given information about what kind of response is desirable. Moreover, he is instructed to adopt a differentiating attitude (to attend to some cues without taking other cues into consideration). In contrast, the instructions in SAE are more open. The aftereffect is presented in a neutral way and the subject is free to interpret for himself what kind of response is desired. Consequently, a broader spectrum of possible motives might underlie a given type of response here as compared with SC_2 and RFT, where the goals are given in the instructions.

Secondly, related to the question of task-interpretation is the problem of conceptual solutions. The calculated (but not perceptually experienced) equality of the circles in SC_2 and the overcompensations in RFT might be seen as the result of such a conceptual approach. The process underlying conceptual solution is, of course, different from that underlying a real shift of focal awareness. On the other hand, it seems that in both cases subjects have an active approach to the task. They actively use methods in their repertoire in order to meet the demands of instructions. This results in their being found on

the SC₂ and RFT to lie on the "more differentiated" side of the continuum which ranges from differentiation to non-differentiation. In contrast, the character of the SAE-situation and the non-directed instructions in this task limit the application of conceptual solutions.

In spite of these task-differences, a strong relationship to SC₂ is evident when SAE duration is combined with the results on RFT. The differentiation between low, high and intermediate SAE duration showed that extreme SAE durations are of particular interest in this context. It may be concluded that individuals with short SAE duration and field-independent RFT performance show a higher ability to perceive in terms of retinal object than individuals with long SAE duration and field-dependent perception on RFT.

The results elucidate an interesting aspect of the interplay between "executive" and peripheral motives. Of central interest was the influence which the normally dominant intention can have on perceptual experience if it is temporarily made peripheral. One can ask whether this influence as demonstrated in SC₂ can be explained exclusively by the "executive" (reality oriented) character of physical size-oriented perception. In other words: Are particular difficulties in attending to the retinal size due to the stronger dependence upon reality? The relationship obtained between high interference of physical-reality oriented perception in SC₂ and long SAE duration negates this interpretation. In contrast to SC₂, the interfering aspects in SAE (i.e. traces of previous stimulation) are not reality-adaptive. Instead, they have a distorting influence on actual reality-perception. The results show that individuals who are most oriented to physical reality in their perception in SC₂ are least influenced by the physical stimulus in the SAE-situation. Consequently, it seems that it is not the reality-adaptive function per se which prevents the experiential shift in SC₂. Rather, the ability to perceive retinal size appears to be an expression of a formal ability to differentiate.

As concerns the relationship obtained between SC_1 - and SC_2 -tasks, one interpretation would be in terms of individual differences in perceptual constancy, stable over a variety of situations. On the same basis, a relationship could be predicted between an analytic (SC_2) and an objective type task. This prediction was made by Jenkin and Hyman (1959). Those authors failed, on the other hand, to obtain the relationship they had predicted and concluded that judgments here do not depend on the perception of retinal size at all. To the present author, however, it appears that the diversity of the processes underlying the perception of retinal size in the "analytic" situation (and also underlying behavior in other tasks) does not allow any simple prediction of this kind. The retinal responses in SC_1 could mean different things. They could represent truly perceptual responses indicative of a mode of perceiving where subjective experience is only partially dominated by physical invariants. On the other hand, the content of the subsequent interview suggested that many subjects tried to apply the conceptual approach both in this task and in SC_2 . It appeared that their high retinal responses in SC_1 were an expression of their belief about what subjective equality should be, rather than of a really experienced equality. Therefore, it does not appear that a high retinality in the "apparent" and "analytic" situations would necessarily lead to an underconstancy in the "objective" situation. It might instead be expected that the present subjects would show overconstant results in the "objective" situation.

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*Children's Understanding of the Spiral Aftereffect
Phenomenon as Related to Aftereffect Duration and
Coordination of Perspectives*

by Jitka Lindén



LUND UNIVERSITY SWEDEN

A b s t r a c t . - Studied understandig of the spiral aftereffect-phenomenon in 66 children aged 7.5 - 8.5 years. Using the "méthode clinique" following the child's inspection of the aftereffect, two main levels of understanding were found: less advanced children considered the aftereffect to be a real object-modification, while more advanced children understood its apparent character. The Ss who understood the apparent character succeeded better in the Coordination of Perspectives-Test. Children more advanced on this test and in their SAE understanding also showed intermediate SAE-durations as compared with the more extreme (short-long) durations in less advanced children. The results are discussed in terms of general development toward objectivity.

I n t r o d u c t i o n

It has previously been shown that a child's perception of visual aftereffects is related to various intelligence functions. Ruuth and Smith (1969) demonstrated a relationship between size and colour of projected afterimages and cognitive maturity as defined by Piaget's tasks. Thus, less mature children (age 4 yrs. 6 mo. - 6 yrs. 10 mo.) were more resistant to size increase with increasing projection distance and also reported more positive hues. A relationship between duration of spiral aftereffect (SAE) and the level of cognitive development was found by Andersson et al. (1969). In their study, children (age 4 - 6 yrs.) who were more successful in conservation and dream-analysis tasks, obtained SAE-durations of intermediate length more often than children less successful at these tasks. The results were interpreted in terms of of a heuristic model which states that extreme SAE-durations reflect an overvaluation of either intraceptive (long-durations) or extraceptive (short durations) factors of perception. Intermediate durations were taken to indicate that the subject has achieved a balance between the two extremes. A developmental paradigm of successively short - long - intermediate durations was proposed.

The study of how children deal with both perceptual and conceptual aspects of a situation seems particularly important for gaining insight into developmental relations between perception

and thinking, which has been largely neglected in research based on Piaget's theory. The SAE-phenomenon seems extremely useful for this purpose. The position of SAE between the child's subjective world and the objective world provides a unique opportunity for studying the child's process of objectification (in the epistemological sense). A pilot study by the author showed that children often thought SAE to represent a real change in the outer world, while adults were quite clear about its only apparent character. It was hypothesized that the gradual understanding of the apparent character of the phenomenon is linked with the development of relation between subject and object.

According to Piaget, the understanding of subjective and objective relations has a long history of development in childhood (e.g. Piaget and Inhelder, 1967). Its final form (the operational level) is characterized by the child's being aware of the laws governing relations among things and relations between his own activity and that of objects. Certain aspects of his awareness of subject - object relations are encountered quite early. Regarding perceptual constancy, for example, the child is already able at the sensorimotor level to distinguish - in practice - between a change of state and of position of an object. In contrast, the child does not achieve an intellectual understanding of this before the age of 7 - 8 years, when he starts to consciously locate himself in a spatial field conceived as external to his body and independent of his actions. At this age, laws governing relationships between an object's real and apparent state begin to be grasped. Prior to this, an intuitive understanding of these relations is always dependent on the concrete content. Thus, the child can recognize whether a particular event is real or unreal (apparent) without being able to use these terms independently of the concrete situation. He invariably fails to employ these concepts for purposes of prediction in a hypothetical situation.

According to Piaget, there is a reciprocity between an understanding of the apparent character of things and the capacity for coordinating perspectives (cf. the Coordination of Perspectives-Test, Piaget and Inhelder, 1967). The awareness of one's own viewpoint thus appears to be dependent upon the awareness of other viewpoints. There seems to be a general system of reference involving relations among things as well as between subject and object. This conception suggests that the mechanism underlying the egocentric reaction observed in children is a lack of differentiation of viewpoints.

The present investigation aims at studying the understanding of the spiral aftereffect during a period which is critical for the process of objectification. It was expected, in light of what has just been said, that the child's understanding of the SAE-phenomenon would be related both to his capacity for coordinating perspectives and to the duration of the aftereffect.

M e t h o d

Participating in the study were 66 children, 30 boys and 36 girls (age range: 7.5 - 8.5 yrs) from three first-grade classes in Lund.

SAE experiment

The apparatus was the same as used by Andersson, Nilsson and Henriksson (1970). The usual procedure for the measurement of SAE-duration was employed. SAE was induced by means of a rotating arithmetic spiral which appeared to the subject as contracting. Immediately after the spiral had been shown, a circle was presented to the subject's field of vision, the circle being perceived as expanding or moving towards him. The instructions were specially adapted for children. The child was to say "stop" when the circle ceased to move. There was one demonstration and one pre-trial, the test proper consisting of 10 massed trials, each with an inspection period of 45 sec. The reported duration was

registered by the experimenter. The usual method of describing individual SAE-duration patterns was employed (cf. Andersson, Ruuth, Nilsson and Smith, 1972).

The child's understanding of SAE-phenomenon was determined by means of a halfstructured interview which followed measurement of SAE-duration. Children were asked about the nature of the circle's growth (or its approach). The main focus of interest was on the child's use of the terms real - apparent. In addition, each child was asked about the origin of the perceived phenomenon.

Coordination of Perspectives-Test

The equipment was a pasteboard model (39 × 39 cm) representing three mountains, four pictures showing the three mountains from different angles and a doll. The child, seated on a chair in front of the model, saw a white mountain (10 cm high) in the foreground, a gray mountain (20 cm high) behind it and to the right, and a black mountain (15 cm high) in the background. In the first part of the experiment, where the pictures were presented, the child was asked to choose the picture showing the mountains from his side. Afterwards, the doll was alternately placed in the middle of each of the remaining sides, the child's task being to choose the picture showing the scene from the doll's point of view.

In the second part of the experiment the child was shown the four pictures one by one, his task being to put the doll at the place from which it could see the picture in question.

Each child made eight choices, the number of errors serving as the variable of interest in data analysis.

R e s u l t s

Analysis of the SAE-test data showed that the predicted relations were more clear-cut for initial SAE-scores than for later SAE-scores. This confirmed the finding of Andersson et al., (1969) that initial scores are particularly meaningful with children. The reported durations in the present study were relatively long, eight children having final scores longer or equal to 30 sec. (Range 0.5 sec - 44.0 sec). Four children failed to report any duration at all: two of them refusing to, one failing to understand the instructions and one having severe behavioral disturbances.

The verbal reports obtained in the second part of the SAE experiment were classified in four categories according to the degree of understanding of the subjective character of the aftereffect. The criteria and the number of subjects in each category were as follows:

- (1) The SAE was described as a subjective phenomenon not existing in reality. The subject considered himself as the source of the SAE and could also give a relevant explanation of the relationship between subject and object. For example: "You get mixed up by the rotating figure". (n = 4).
- (2) The SAE was described as a subjective phenomenon (neither its apparent growth nor its approach toward him being considered as real) without the child's being able to offer any relevant explanation of it. (n = 16).
- (3) The SAE was described as a real modification of the circle. If the subject did grasp the apparent character of the perceived growth, he explained it as being the result of a change in the distance (i.e. approach) or vice versa. (n = 27).

- (4) A complete unawareness of the relationship between the subject and the object was in evidence. The SAE was considered as a real object-modification. (n = 9).

Children belonging to the categories (1) and (2) were considered as more advanced in their understanding of the SAE-phenomenon than those belonging to the categories (3) and (4). Six individuals did not offer any verbal report and could not be classified. They all had extreme durations of SAE.

Approximately half of the children had less than two errors on the Coordination of Perspectives-Test. However, as appeared in their verbal explanations, the solutions were mostly intuitive, based on momentary insights. None of the children offered a complete verbal explanation which included all the projective relationships. Nevertheless, children with two or more errors were considered to be less advanced in their understanding of the coordination of perspectives than those with zero or one error. Table 1 shows the distribution of the subjects on all the tests.

Table 1. Distribution of subjects in the Spiral Aftereffect Test and Coordination of Perspectives-Test.

	<u>CPT: less advanced</u>			<u>CPT: more advanced</u>		
	<u>SAE_{il}: low interm. high</u>			<u>SAE_{il}: low interm. high</u>		
SAE _c : less advanced	8	9	9	3	5	2
SAE _c : more advanced	0	2	1	2	13	2

Note: The low and high groups on the SAE variable were defined in terms of the upper and lower quartiles (SAE <11.0 sec and SAE ≥24.5 sec, respectively). For definition of more and less advanced groups, see text.

Table 2 shows the relation between understanding of the SAE and the results of the Coordination of Perspectives-Test. As expected, children who were more advanced in their understanding of SAE succeeded better in the Coordination of Perspectives-Test.

Table 2. Relation between SAE-understanding and results of Coordination of Perspectives-Test.

GROUP	SAE _C : more advanced	SAE _C : less advanced
CPT: more advanced	17	10
CPT: less advanced	3	26

P = 0.00004 (one-tailed, Fisher's exact test).

The relation between duration of SAE and understanding of it is shown in Table 3. As predicted, children who were more advanced in their understanding of SAE showed intermediate SAE-durations, while those less advanced had either short or long SAE-durations.

Table 3. Relation between the understanding of SAE and its duration.

GROUP	SAE _C : more advanced	SAE _C : less advanced
SAE ₁₁ ^{low} or high	5	22
SAE ₁₁ ^{interm.}	15	14

P = 0.009 (one-tailed, Fisher's exact test).

As evident in Table 4, there was also a relation between the capacity to coordinate perspectives and the duration of SAE. Chil-

dren who were less successful in coordinating perspectives obtained extreme (short - long) SAE-durations more often than children who were more successful, the latter obtaining intermediate SAE-durations.

Table 4. Relation between the results of the Coordination of Perspectives-Test and SAE₁₁-duration.

GROUP	SAE ₁₁ low or high	SAE ₁₁ interm.
CPT: less advanced	21	12
CPT: more advanced	10	19

P = 0.02 (one-tailed, Fisher's exact test).

D i s c u s s i o n

The results indicate an interdependence between the level of thinking as revealed by SAE-understanding and by the Coordination of Perspectives-Test, and also between this and the child's SAE-perception. An interpretation of these results could be in terms of the overcoming of egocentrism in both perception and thinking. While the validity of this interpretation in general need not be questioned, the concrete picture remains somewhat obscure. It can be asked, for example, why some subjects overvalue nonself-aspects (by showing short SAE-durations), while others overvalue self-aspects (by showing long durations). In the opinion of the present author, difficulties in analyzing this problem are partly linked with the very term "egocentrism". The origins of egocentrism are found - as already pointed out - in the limited awareness of both "self" and "nonself". Consequently, the ego-centered approach seems just a particular case of a centered approach in general, one

which depends on the lack of differentiation between subject and object. This centered approach can have very different effects - hence the paradox of choosing one's own perspective in the Coordination of Perspectives-Test and the inability to describe one's own perspective in other situations (e.g. in drawing). Ontogenetic development can be described as a process of overcoming this lack of differentiation. While the direction of this process tends toward increasing awareness of relations between subject and object, the concrete form the process takes can be quite different for different modes of cognition (perception, thought), and for different situations and persons.

The reasoning above can be illustrated by the following scheme (which possesses all the limitations of schematic illustrations in general, namely static character and inability to describe the course of development).

LACK OF DECENTRATION ————— DECENTRATION

Examples:

- | | |
|--|---|
| - egocentric reaction | - coordination of perspectives |
| - inability to describe one's own perspective | - understanding of projective relations |
| - no understanding of "real" and "apparent" character | - understanding of "real" and "apparent" character |
| - overemphasis of self or non-self aspects of perception | - differentiation of self and nonself aspects of perception |

The question can be raised as to the generality of the demonstrated relationship between perception and thinking. A relationship similar to the one demonstrated here is rather difficult to find in the literature. More frequently, temporal displacement between the two spheres of achievement has been shown. For ex-

ample, Piaget and Inhelder (1967) report temporal displacement between the recognition of a straight line and its reconstruction at a representational level. Even a longer time-gap is reported between the achievement of perceptual constancy as such and the understanding of it. The lack of such displacement in the case of SAE can be partly explained by the specific nature of the SAE-phenomenon: The child sees it for the very first time. Thus, he has little help from automatized modes of perceiving (cf. perceptual constancy). Instead, he is required to activate the entire complex of his abilities in order to orient himself to the new situation. It would seem that the child who has more highly developed qualities of thinking is better equipped for doing this.

R e f e r e n c e s

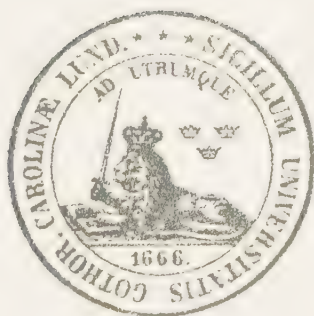
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*A Longitudinal Study of the Spiral Aftereffect
Phenomenon and the Ability to Coordinate
Perspectives*

by Jitka Lindén



LUND UNIVERSITY SWEDEN

A b s t r a c t . - Performed two follow-ups, each after a one year interval, of a study of perception of the spiral aftereffect (SAE), the understanding of the SAE-phenomenon and the ability to coordinate perspective (CPT) in 66 children aged 7.5 - 8.5 years when first tested. A linear age trend indicating a decrease in the SAE-duration between ages 8 - 10 years was found. The final SAE-duration in a series of 10 showed higher stability (range of correlation coeff. 0.28 - 0.39) than did the initial duration (0.13 - 0.21). Patterns of individual age change with respect to short - long - intermediate durations were studied. Understanding of the SAE-phenomenon increased with age, as did the ability to coordinate perspectives. The inter-relation found at age 8 years between the level of cognitive development and the SAE-duration was not found at age 9 or 10 years.

I n t r o d u c t i o n

In a previous study by the present author (Lindén, 1977) a relationship between conceptual and perceptual task-acquisition in children aged 7.5 - 8.5 years was shown. It was found that, in a series of 10 trials, the initial duration of the spiral aftereffect was related to the understanding of the aftereffect phenomenon. Children who grasped the apparent character of the SAE showed intermediate SAE-durations as compared with either long or short durations in children who considered the aftereffect to be a real object-modification. The latter children also achieved fewer correct solutions on the Piaget Coordination of Perspectives Test. The present study aims at exploring these variables (i.e., SAE-perception, SAE-understanding and coordination of perspectives) and their interrelations as the child grows older. It consists of two follow-ups of the original study, each after a one year interval.

SAE-perception

Besides focusing on interindividual differences in SAE-duration as related to levels of conceptual development, previous developmental studies of SAE have aimed at tracing changes in SAE-regulation in relation to chronological age. Andersson et al. (1969) demonstrated the intermediate SAE-duration to be more prevalent in 6 year old children than in those aged 4 or 5 years. The 4-year-olds more often showed short SAE-duration and the 5-year-olds more often long. Of particular interest for our purposes here was the retest-

ing of 20 children (out of 31) one year later. Children age 4 years who had short initial durations on the first test increased SAE-durations on the second, while children with long durations, irrespective of age, decreased SAE-durations. These data were epitomized in the three-step developmental paradigm short-long-intermediate SAE-durations. Initially, the child's awareness seems directed mainly toward factors in his immediate environment, referred to as nonself or extraceptive factors. This shows up as short SAE-durations. Following this, a heightened awareness of his internal world (intraceptive, self factors) appears, as implied by long reported SAE-durations. Finally, the child reaches a stage of relative autonomy from both extraceptive and intraceptive factors, which is reflected in intermediate durations.

In a cross-sectional study including age levels 7, 9, 11, 13, and 15 years (Andersson et al., 1977), a linear trend was revealed representing a successive decrease in initial durations with age. On the other hand, an analysis of final durations showed a quartic trend attributable to a re-appearance of long aftereffect durations among 11 year old subjects. In the same study, a general model attempting to extend the three-step developmental paradigm within the framework of overall cognitive development was outlined.

Against this background, interest here is threefold: (1) overall change in SAE-durations with age, (2) individual stability of SAE-durations with increasing age, (3) individual developmental functions describing the mode of relationship between an individual's age and the change in his perception of SAE. Since most studies of SAE-perception differentiate between low, medium and high durations of aftereffect, possible developmental changes of the individual's classification in these terms were of particular interest.

Interrelations between the variables

As concerns the relationship found in the original study between understanding of the SAE-phenomenon and results of the Coordination of Perspectives Test, there are reasons within Piagetian theory to assume a consistency in the relationship between results of these two tests during development. First, there is the assumption of a common structural basis underlying the two situations, involving the development of subject-

object relations which lead to the coordination of viewpoints in CPT and to an understanding of the apparent nature of the SAE-phenomenon. Second, there is the assumption of a synchronous development of behaviors on a common structural basis. On the other hand, it appears that there are certain difficulties in confirming these predictions empirically. Among the factors contributing to these difficulties are the considerable inconsistencies in behavior during the transitional stage. According to Laurendau & Pinard (1970), who largely confirmed the original stage-typical development of coordination of perspectives postulated by Piaget & Inhelder (1967), transitional behavior might be expected at the ages relevant for our study. Further, there is the still open question of horizontal d é - c a l a g e (i.e. the fact that structurally equivalent behaviors are sometimes acquired with certain temporal displacement) which disturbs the synchronization of analogous developments.

Even greater problems are faced with regard to the relationship between the perception of SAE-duration and the understanding of the SAE-phenomenon. The fundamental structural differences between perception and conception in Piaget's theory are well known; since stages in perceptual development are lacking there is no common structural basis there similar to that discussed above. On the other hand, Piaget's method of comparing perceptual and conceptual structures in their extreme or final forms has been criticized for obscuring the assumed developmental inter-relatedness between the two. As regards developmental aspects here, it can be shown that perceptual activities lead to comparisons involving increasing distances in space and time. This means, in the case of the SAE-phenomenon, that the initial focus on either self or nonself aspects gradually becomes decentered due to the construction of perceptual coordinates relating both to one's own body and to external objects. True, the two aspects (self - nonself) are always present in

perceptual awareness; it is characteristic of perception that the parts simultaneously present in the field interact. However, the point to be stressed is that this interaction is subjected to developmental change characterized by increasing equilibrium between its components.

M e t h o d

There were 66 children, consisting of 30 boys and 36 girls (mean age 7.9, median age 8.0, age range 7.5-8.5 years), who participated in the original study. These subjects were re-tested twice, each time after a one year interval. Table 1 shows the distribution of subjects on the three test occasions. Eight children moved from the town during the experiment. One boy showed severe behavioral disturbances on all occasions and was excluded from the study. A total of 57 children participated on all test occasions. The experimental conditions were kept constant. The same person served as experimenter on all occasions.

Table 1. Distribution of subjects on the three test-occasions.

	Boys	Girls	Out
AGE			
7.5 - 8.5	29	36	1
8.5 - 9.5	27	31	7
9.5 -10.5	27	30	1

SAE-perception

The standard procedure for the measurement of SAE-duration and the description of individual SAE-duration patterns was employed (Andersson et al., 1972). The SAE was induced by means of a rotating arithmetic spiral which appeared to the subjects as contracting. Immediately after the spiral had

been shown, a circle was presented to the subject's field of vision, the circle being perceived as expanding or moving towards him. The subject's task was to say "stop" when the aftereffect on the circle ceased. There was one demonstration and one pre-trial. The test proper consisted of ten massed trials, each beginning with a spiral inspection period lasting 45 seconds. The reported duration was registered by the experimenter. The data analysis was based on individual initial SAE durations ($i1 = t_1 + t_2 / 2$), mean durations ($m1 = t_1 + t_2 + \dots + t_{10} / 10$) and final durations ($f1 = t_9 + t_{10} / 2$).

SAE understanding

The child's understanding of the SAE-phenomenon was determined by means of a half-structured interview which followed measurement of the SAE-duration. Children were asked about the nature of the circle's growth (or its approach). The main focus of interest was on the child's use of the terms real and apparent. In addition, each child was asked about the origin of the perceived phenomenon. In the original study, the verbal reports were classified in four categories according to degree of understanding of the subjective character of the aftereffect. The criteria for this classification were as follows:

- (1) A complete unawareness of the relationship between the subject and the object was in evidence. The SAE was considered as a real object-modification.
- (2) The SAE was described as a real modification of the circle. If the subject did grasp the apparent character of the perceived growth, he explained it as being the result of a change in distance (i.e. approach).
- (3) The SAE was described as a subjective phenomenon (neither its apparent growth nor its approach towards him being considered as real) without the child's being able to offer any relevant explanation of it.
- (4) The SAE was described as a subjective phenomenon not existing in reality. The subject considered himself as the source of the SAE and could also give a relevant explanation of the relationship between subject and object, e.g. "You get mixed up by the rotating figure".

The intention here was to use these categories as a frame of reference in analysing the data of the two follow-up studies.

Coordination of Perspectives-Test

The equipment was a pasteboard model (39 × 39 cm) representing three mountains, four pictures showing the mountains from different angles, and doll. The child, seated on a chair in front of the model, saw a white mountain (10 cm high) in the foreground, a grey mountain (20 cm high) behind it and to the right, and a black mountain (15 cm high) in the background. In the first part of the experiment, when the pictures were presented, the child was asked to choose the picture showing the mountains from his side. Afterwards, the doll was alternatively placed in the middle of each of the remaining sides, the child's task being to choose the picture showing the scene from the doll's point of view.

In the second part of the experiment the child was shown the four pictures one by one, his task being to put the doll at the place from which it could see the picture in question.

Each child made eight choices, the number of errors serving as the variable of interest in the analysis.

R e s u l t s

Spiral aftereffect perception

Of the 57 children who participated on all three occasions, 51 children reported all ten SAE-durations on each of the occasions. Three of the 57 did not see any aftereffect at all and three failed to complete the ten trials on the first test occasions (age 8), having very long aftereffect durations and becoming bored after a few trials. Therefore, analysis of the initial SAE-duration involves 54 individuals but analysis of mean and final durations only 51.

(1) Overall longitudinal change in SAE-durations.

Ages together with the mean SAE-durations for the variables il , ml and fl are shown in Table 2. The related mean curves are found in Fig. 1. There appears to be a tendency for SAE-durations to decrease with age. The tendency to decrease is most pronounced at the final level, while at the initial level the situation is less clear. The picture here depends upon whether the three girls with very long initial durations at age 8 years are included in the analysis. When ex-

cluded, initial durations at age 9 are slightly higher than those at age 8 years. On the other hand, according to other studies (Andersson et al., 1977), very long durations seem to be typical of 7 - 8 year old girls, suggesting these to not be the result of irrelevant or chance factors.

Table 2. Average SAE-duration (in seconds) at ages 8,9 and 10 years.

Age	8	9	10
SAE-il	18.8	16.9	12.6
SAE-m1	15.2	14.5	11.4
SAE-fl	15.1	13.9	10.1

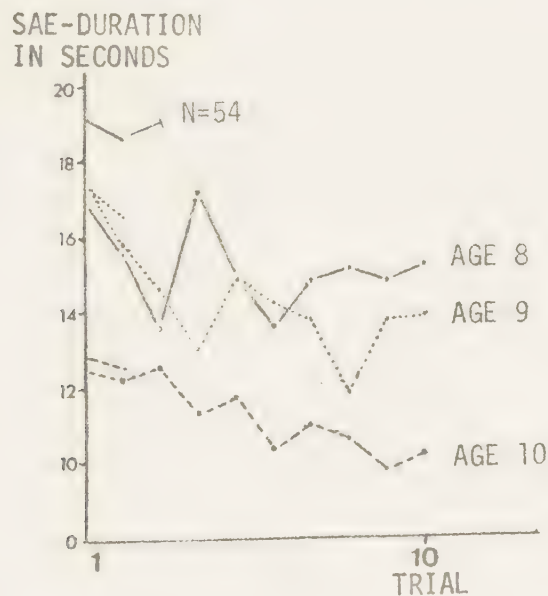


Fig. 1. Average duration of SAE at different ages.

Since longitudinal changes with age rather than age differences as such were the focus of our interest, trend characteristics describing age changes from 8 to 10 years were estimated (test

for trend, adapted for repeated measures, Winer, 1962). The analysis (Table 3) shows a linear age trend indicating successively decreasing SAE-durations from 8 to 10 years.

Table 3. Analysis of variance involving longitudinal changes in SAE-duration between ages 8-10 years.

Source of variation	df	F		
		il	ml	fl
Age	2	4.38 ⁺	4.59 ⁺	5.59 ⁺⁺
linear	1	8.4 ⁺⁺	8.17 ⁺⁺	10.19 ⁺⁺
quadratic	1	0.59	0.95	0.94

++ : $P < 0.01$, + : $P < 0.05$, v two-tailed test.

(2) Individual stability in SAE-duration at ages 8-10 years.
The amount of change in the position of the individual relative to others during the age span in question is shown in Table 4. Higher stability coefficients, although of only moderate size, are found for final SAE-durations than for initial durations.

Table 4. Correlations (Spearman rank coefficients) between SAE-durations at different ages.

Age	8 - 9	9 - 10	8 - 10
SAE-il	.13	.15	.21
SAE-ml	-.08	.25	.33
			$P < .01$
SAE-fl	.33	.28	.39
	$P < .01$	$P < .05$	$P < .01$

Note: $N(il)=54$, $N(ml,fl)=51$. P-values refer to two-tailed tests.

(3) Types of individual change in SAE-duration during ages 8 - 10 years.

In addition to the degree of individual stability in SAE-durations, types of individual change with age were studied. First, individual durations at different ages were classified in durational categories low (L), medium (M) or high (H), using the upper and lower quartiles for the age in question (Table 5). Individual change-patterns were determined by tracing a subject's changes with age within the durational category shown. For example, if an individual showed low SAE-duration at age 8 years, medium duration at age 9 and low duration again at age 10, his change-pattern was characterized as LML (sign $\wedge$). Table 6 shows the distribution of these individual patterns.

The primarily increasing change-patterns of originally low SAE-durations can be interpreted as artifacts, as can the prevalently decreasing change-patterns of originally high SAE-durations. Intermediate SAE-durations at age 8 are followed by both increasing and decreasing change-patterns. Table 7 shows the relationship between the pattern of longitudinal change in SAE-duration and SAE-duration at age 8 years. The highest frequency is obtained for patterns indicating a change over one level (e.g. LML or LLM), while patterns indicating change over two levels (e.g. LHM or LHH) or no change at all (e.g. LLL) are much less common. Change over 2 levels occurs about twice as frequently, both as regards the initial and the final SAE-levels, among subjects who originally (at age 8) had either low or high SAE-scores than among subjects whose original scores were intermediate. However, no general significant relationship between the pattern of longitudinal change and the original SAE-duration was found.

Table 5. The definition of low and high SAE-durations in terms of upper and lower quartiles at ages 8, 9 and 10 years.

Groups			
age 8 yrs	SAE-il	<10.25	>24.5
	ml	< 8.45	>19.55
	fl	< 8.25	>19.55
age 9 yrs	SAE-il	<11.25	>21.25
	ml	< 8.1	>18.55
	fl	< 5.5	>19.5
age 10 yrs	SAE-il	< 5.5	>20.5
	ml	< 6.8	>16.2
	fl	< 4.5	>12.75

Table 6. The distribution of individual change-patterns.

Change-pattern	LLL	LML	LLM	LMM	LHM	LHH	LHL
Low SAE-duration at age 8 yrs	4	2	2	3	2	0	0
	2	1	4	4	1	1	1
	1	3	4	3	2	0	0

	MMM	MHM	MMH	MHH	MLH	MLM	MML	MHL	MLL
Medium SAE-duration at age 8 yrs	7	2	2	4	1	4	4	1	0
	5	4	6	0	3	2	4	1	1
	8	2	3	3	1	3	2	1	2

	HHH	HHM	HMH	HMM	HLL	HML	HLM	HHL	HLH
High SAE-duration at age 8 yrs	2	4	2	2	1	1	1	0	0
	2	2	1	4	1	1	1	2	0
	4	1	0	2	0	3	1	1	1

Table 7. Patterns of individual longitudinal change in SAE-duration related to duration at age 8 years.

(a) SAE-initial level

Type of change		over 2 levels	over 1 level	no change
SAE-duration at age 8 yrs	LOW	3 (21.4%)	9 (64.3%)	2 (14.3%)
	MEDIUM	4 (15.4%)	17 (65.4%)	5 (19.2%)
	HIGH	5 (35.7%)	7 (50.0%)	2 (14.3%)

(b) SAE-final level

Type of change		over 2 levels	over 1 level	no change
SAE-duration at age 8 yrs	LOW	2 (15.4%)	7 (53.8%)	4 (30.8%)
	MEDIUM	2 (8.0%)	16 (64.0%)	7 (28.0%)
	HIGH	3 (23.1%)	8 (61.5%)	2 (15.4%)

Understanding of the SAE-phenomenon

The same method of classification of verbal responses was used as in the original study. In addition, two other categories (00 and 01, respectively) were used for children who did not see any aftereffect at all or who did not offer any verbal report. Table 8a - c illustrates longitudinal stability and change in SAE-understanding.

In conclusion, development of SAE-understanding between ages 8 - 10 years is characterized by an increase in understanding of the SAE-phenomenon. There is also an increasing stability in responses with age. It can be seen that between ages 8 and 9 nearly 14% of the children dropped in performance, their responses being classified as less satisfying in the second test. Between ages 9 and 10, this proportion is only 4.6%. Table 9

shows the proportion of the children in SAE-categories at different ages. Responses regarded as "more advanced" (.i.e., 3 4) and "less advanced" (1 and 2) tend to cluster into two groups: category (4), with complete SAE-understanding, and category (2). The other categories, (3) and (1), almost disappear at age 10. Three of the five children classified in category (3) at age 10 answered that they were not sure if the circle had really grown or if it only seemed to grow because of the rotating figure. Obviously, these children understood subject-object differences although they could not decide what the correct alternative was in the present case.

Table 8. Longitudinal stability and change in SAE-understanding. Distribution of subjects.

(a) Age 8 and 9 years

Age 9, category		00	01	1	2	3	4	out
Age 8, category	00	1		1	1			
	01				4		1	1
	1			1	1	3	2	2
	2	1	1		14	3	5	3
	3	1			4	4	6	1
	4					2	2	

(b) Age 9 and 10 years

Age 10, category		00	01	1	2	3	4	out
Age 9, category	00	1			1			1
	01				1			
	1			1	1			
	2				12	1	11	
	3				3	4	5	
	4						16	
	out							7

Table 8 (c). Longitudinal stability and change in SAE-understanding.

Group	no change	progression	regression	out
Age 8- 9 yrs	33.9%	41.5%	13.8%	10.8%
Age 9-10 yrs	52.3%	30.8%	4.6%	12.3%

Progression/ age 8-9 yrs:sign test $P=.002$, one-tailed test.
 regression: age 9-10 yrs:sign test $P=.001$.one-tailed test.

Table 9. Proportions of subjects in SAE-categories at different ages.

Group	more advanced		less advanced			
category	4	3	2	1	00/01	out
Age 8 yrs	4 30.8%	16 55.4%	27	9	13.8%	-
Age 9 yrs	16 43.1%	12 40.0%	24	2	6.1%	10.8%
Age 10 yrs	32 56.9%	5 29.3%	18	1	1.5%	12.3%

Coordination of Perspectives Test

As can be seen in Table 10, ability to coordinate perspectives increased progressively between ages 8-10 years. Only 6.2% of the children aged 10 years made more than one error in the Coordination of Perspectives Test. Table 11 indicates an increased stability over the years. The proportion of children falling backward (i.e. showing an increasing number of errors on successive test occasions) decreased from 9.2% at ages 8-9 to 1.5% at ages 9-10.

Table 10. Proportions of centered and decentered solutions of Coordination of Perspectives Test at different ages.

Group	more advanced	less advanced	out
Age 8 yrs	47.7%	52.3%	-
Age 9 yrs	56.9%	32.3%	10.8%
Age 10 yrs	81.5%	6.2%	12.3%

Children with more than 1 error at CPT were considered as "less advanced".

Table 11. Longitudinal stability and change in results of Coordination of Perspectives Test.

Group	no change	progression	regression	out
Age 8- 9 yrs	56.9%	23.1%	9.2%	10.8%
Age 9-10 yrs	60.0%	26.2%	1.5%	12.3%

Progression/ age 8- 9 yrs: sign test $P = .039$, one-tailed test.
regression: age 9-10 yrs: sign test $P = .001$, one-tailed test.

No relationship between the Coordination of Perspectives Test and SAE-understanding or between the Coordination of Perspectives Test and SAE-duration at age 9 years reached the 0.05 level of significance. At age 10, the analysis of these relations became meaningless since more than 80% of the children succeeded with one error or less on the CPT. As concerns relations between SAE-duration and SAE-understanding, no relation was found at age 9 or 10 years.

D i s c u s s i o n

In conclusion, as concerns general ontogenetic changes in SAE-duration, the present study confirms previous cross-sectional

findings of successive decreases in SAE-duration between the ages of 8-10 years. Regarding individual stability of SAE-duration with age, there appears to be a difference between initial and final SAE-durations. The final durations are more stable with age than are the initial levels.

For the purpose of better description of individual development the individual patterns of change in respect to the categories low - intermediate - high SAE-duration were studied. The most frequent patterns appears to be change over one level, while two-level change or no change at all are relatively rare. In accordance with expectations, the understanding of the SAE-phenomenon increased with age, as did the ability to coordinate perspectives. However, the relationship previously shown at age 8 between the SAE-understanding and the results on the Coordination of the Perspectives Test, indicating consistency between tests in the level of thinking attained, was not found here for the ages 9 and 10.

These results, on the other hand, can be interpreted as artifacts of the method of measurement rather as than indicating a real absence of developmental inter-relationship between the two. For the purpose of comparison, the same method of measuring ability to coordinate perspectives which had been shown to differentiate satisfactorily at age 8 years, was employed again at ages 9 and 10. This method, being nonverbal, in contrast with the method for measuring SAE-understanding, has been shown to be too easy for 10 year old children. However, the impression was gained that many of the responses at this age level were still intuitive, without showing proper understanding of all the projective relations involved. Indeed, according to various authors (e.g. Laurendau & Pinard, 1970), traces of egocentrism are found up to the age of 12 years. In addition, the relationship found at age 8 years between level of thinking and SAE-perception did not appear at age 9 and 10 years. One possible explanation could be that in older children the initial duration no longer

depends on an individual's actual knowledge but begins to reflect a cognitive style, as has been shown to be the case in adults (Lindén, 1976).

As far as the possible effects of retesting with the same stimulus material are concerned, if a sufficient degree of "novelty" in the adaptation situation is required, a certain leveling of the aftereffect process might be expected from one testing occasion to the next. In fact, Andersson (Andersson, Nilsson, Ruuth & Smith, 1972) reported a general decrease in the SAE-duration of adults in retests after a two-week interval. On the other hand, it seems improbable that the decreasing age trend observed in the present study is due to these retesting factors. First, a one year interval between the test occasions should guarantee a sufficient degree of novelty in the situation for the children here. They seemed, in fact, to have only a very diffuse memory of the previous test occasion, if indeed they recalled it at all. Moreover, as already mentioned, a decreasing SAE-age trend was likewise found in the developmental cross-sectional study employing different subjects at each occasion.

It would seem that, as regards the interpretation of SAE-performance levels, the initial and final levels have different meanings. Although both *il* and *fl* give information about an individual's regulation of the relationship between his inner and outer world, the final level seems to have the character of a basic personality factor, being relatively stable in the sense of individual consistency during development. The initial level, on the other hand, seems more variable in the sense of being more sensitive to developmental changes based on the acquisition of new methods of cognitive regulation (e. g. the acquisition of conceptual understanding at ages 7-8 years).

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